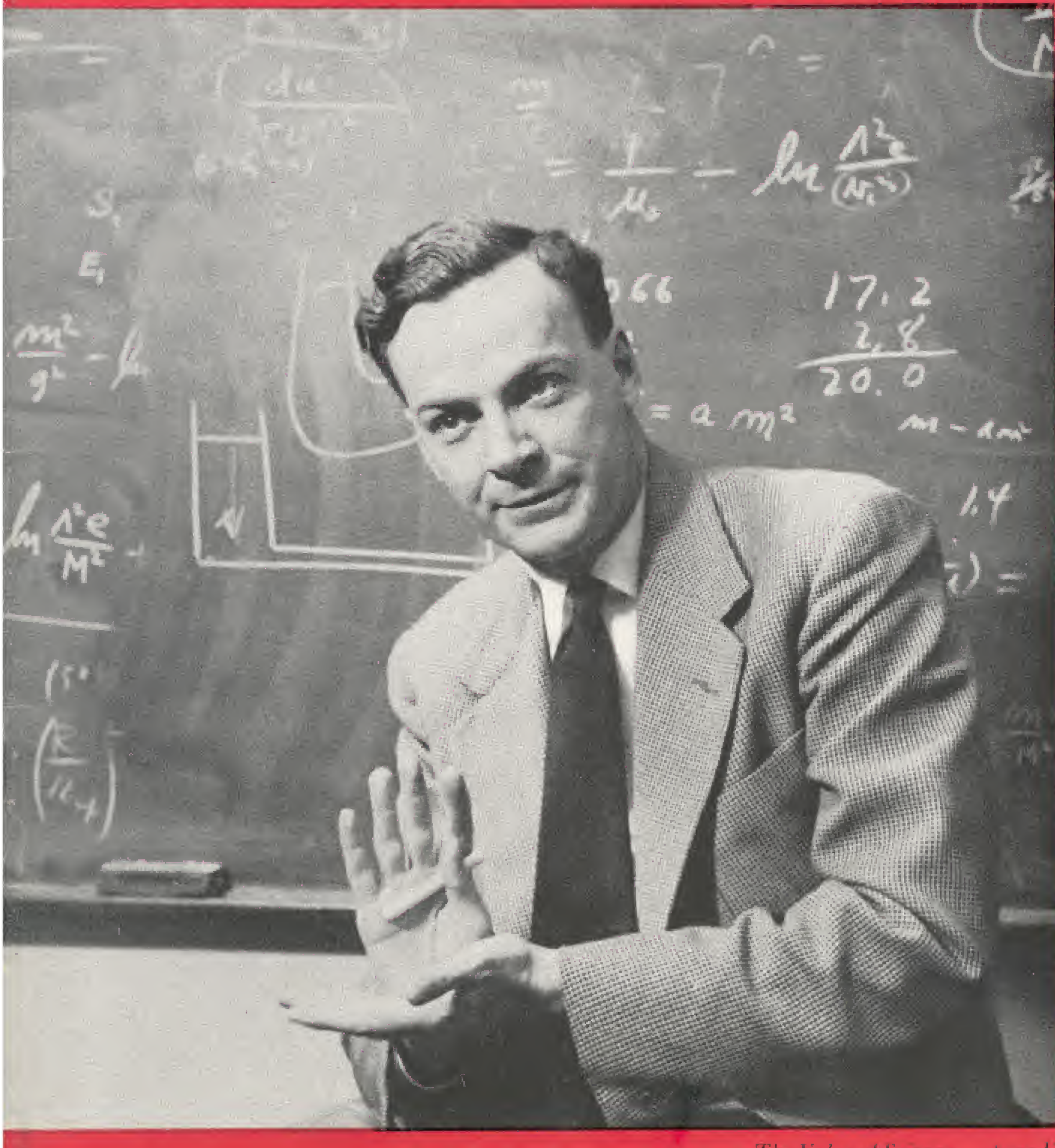
ENGINEERING | AND | SCIENCE

DECEMBER/1955



The Value of Science . . . page 13

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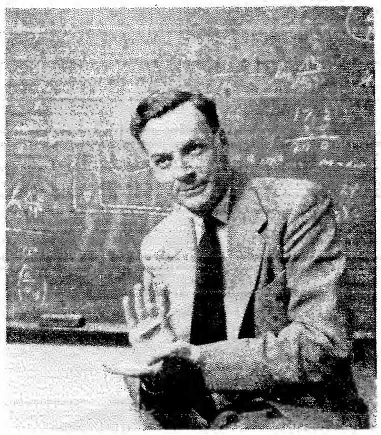
ENGINEERING AND SCIENCE

IN THIS ISSUE



On the cover this month is Richard P. Feynman, Caltech professor of theoretical physics and author of "The Value of Science," on page 13 of this issue. "The Value of Science" was originally given as a public lecture at the annual fall meeting of the National Academy of Sciences, held on the Caltech campus last month.

President L. A. DuBridge's article on "The Air Pollution Problem," on page 18 of this issue, is the first statement to come from the new chairman of the Board of Trustees of the Air Pollution Foundation; Dr. DuBridge was appointed to this position last month, succeeding Raymond B. Allen, chancellor of the University of California at Los Angeles. Dr. DuBridge was one of the founders of the independent Air Pollution Foundation, a scientific organization devoted to the elimination of smog.

"The Air Pollution Problem" was originally given as a talk to the Kiwanis Club of Pasadena on December 1.

Ruth D. Bowen, who wrote "Good Samaritans, Inc.," on page 32 of this issue, is one of the rare feminine contributors to this publication. She is publicity chairman of the Caltech Service League (which she writes about in this issue), the wife of William H. Bowen, superintendent of Caltech's Guggenheim Aeronautical Laboratory, and the mother of Stuart Bowen '56, the E & S staff photographer.

PICTURE CREDITS

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BOOKS

INTRODUCTION TO MODERN PHYSICS
Fifth Edition
by F. K. Richtmyer, E. H. Kennard and T. Lauritsen
McGraw-Hill $8.50

THIS SURVEY of twentieth century physics has long been a standard intermediate text—designed, in general, for students at the senior-college or first-year-graduate-school level. It was originally written by the late F. K. Richtmyer; in subsequent editions, E. H. Kennard, former professor of physics at Cornell University, became co-author with him.

Now, in this fifth edition of the book, which covers advances in the field over the last seven years, a new co-author has been added. Thomas Lauritsen, Caltech professor of physics, has rewritten the final chapters on cosmic rays and nuclear physics, which now include material on some of the newly-discovered fundamental particles, while Professor Kennard has brought the remainder of the book up to date by rewriting, rearangement and abbreviation of older material, to reflect the further change in perspective in the physical scene.

THE ATOMIC NUCLEUS
by Robley D. Evans
McGraw-Hill, 1955 $14.50

Reviewed by Ward Whaling
Assistant Professor of Physics

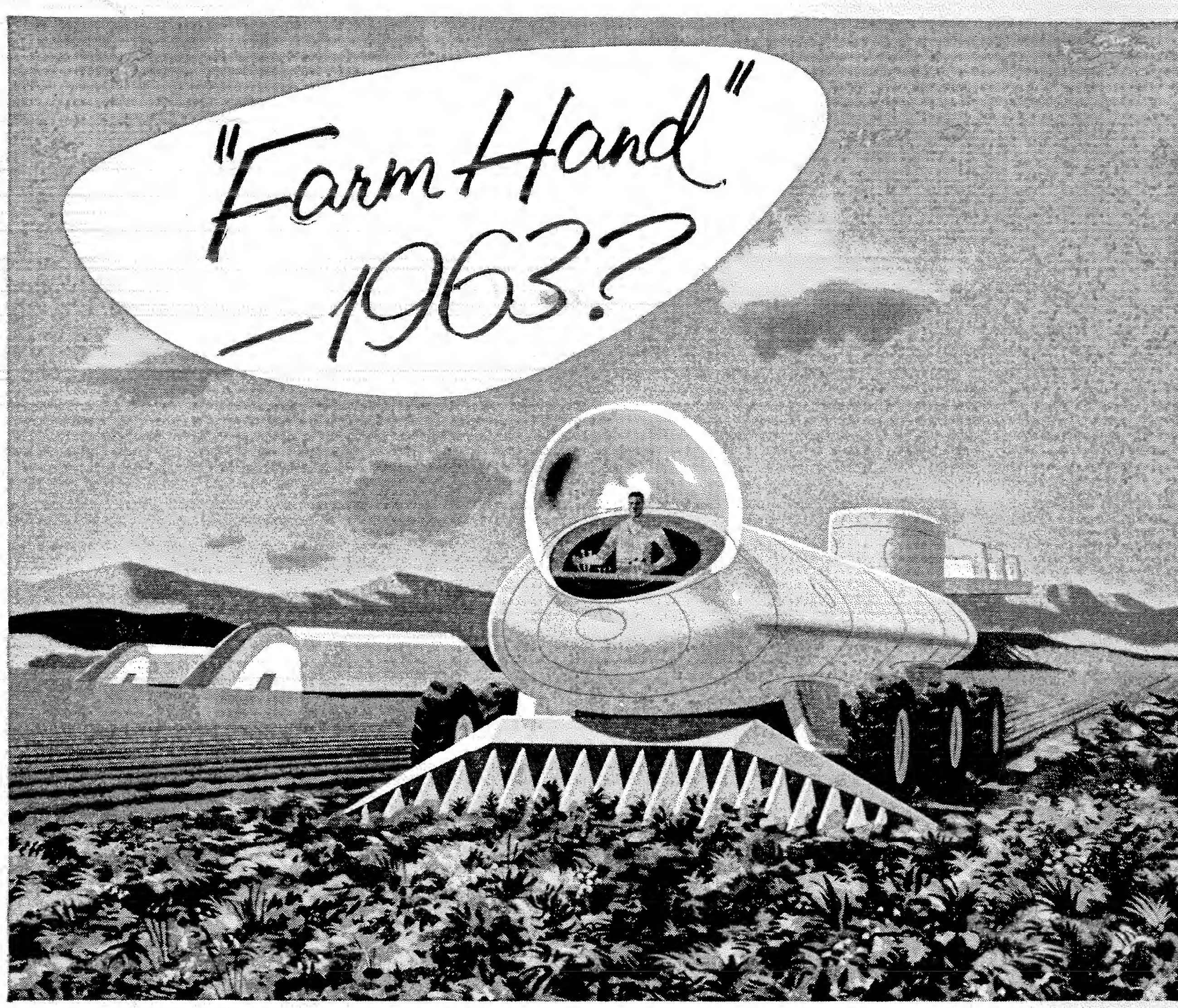
PROFESSOR EVANS has produced a new text book that will be widely used in introductory nuclear physics courses at the graduate level. The book represents a new viewpoint in nuclear physics texts in that it is designed specifically to meet the needs of experimental students who are just beginning their laboratory work. However, it is in no sense a laboratory manual; there is no discussion of experimental technique nor of the apparatus of nuclear physics. The treatment of counters illustrates the aim of this book to supplement concurrent laboratory experience; instead of a description of particular types of counters one finds a thorough discussion of the physical principles of ionization, excitation, scattering, and brehmstrahlung, the basic phenomena which govern operation of all nuclear counters.

In an effort to make the book of maximum utility to beginning students, only the unavoidable minimum of quantum mechanics is employed. The author presumes only a working knowledge of the calculus and some familiarity with atomic physics. Theory is introduced only as it is needed to interpret experiment and the book will not appeal to students whose interest is primarily theoretical.

Starting with the fundamental static properties of nuclei in the first nine chapters, the author proceeds in the next eight chapters to a consideration of nuclear forces and nuclear models, nuclear reactions, radioactive decay, and the conservation laws of nuclear dynamics.

These first seventeen chapters make

NEW DEPARTURES OF TOMORROW



How you gonna keep 'em *away* from the farm after they've seen this machine? . . . Chances are, the people who develop this soil-conditioner, fertilizer-planter unit, with its air-conditioned control cab, will call on New Departure for ball bearings. Maybe they'll just need New Departures that are already in world-wide use—like the Sealed-for-Life or the double-row angular-contact ball bearings. Or they might want an entirely new type—a "new departure" in ball bearing design. Either way, New Departure is the answer. Manufacturers everywhere know that New Departure always lives up to its name—being *first* with the finest in ball bearings.

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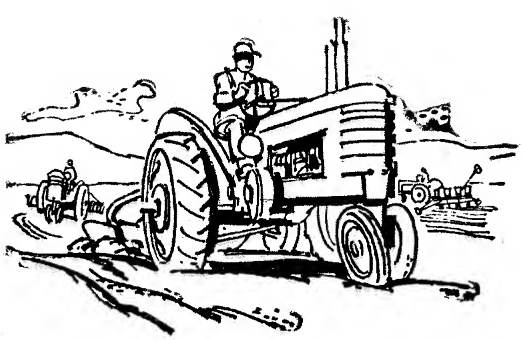

Today, New Departures are used by almost every manufacturer of farm equipment. That's because New Departure ball bearings have proved their ability to carry *all* loads, preserve accurate alignment of moving parts, cut friction and upkeep.

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BALL BEARINGS
NOTHING ROLLS LIKE A BALL

up the core of most introductory courses in nuclear physics; Professor Evans' treatment of this basic material is much more thorough than that in any previous book attempting to cover this broad field. Experimental students will especially welcome the sections on the interpretation of the results of angular distribution, angular correlation, and excitation experiments. Frequent reference to the historical development of our present picture of the nucleus adds interest to the exposition of this material and helps to orient the student who is making his first introduction to the subject. Abundant references to the original research papers are provided for those who wish to pursue their particular interests further; more than a thousand entries appear in the bibliography. The author's rather discursive style will be popular with students; I have never heard my students object to a text because the ratio of prose to equations was too high.

Following the discussion of the nucleus itself are eight chapters on the interaction of charged particles and electromagnetic radiation with matter. The excellent treatment of this subject which has been Professor Evans' own particular research interest for many years, cannot be found elsewhere and will appeal especially to radiobiologists and radiochemists and others who are interested in the physical effects of nuclear radiation. Another feature that cannot be found in other texts is the extensive treatment of the application of statistical theory to the problem of counting random events; the last three chapters of the book are devoted to this subject.

Caltech alumni will be interested to know that this text is now being used in the graduate nuclear physics course here. Professor Evans, now at M.I.T., is a Caltech alumnus himself, having received his BS here in 1928, his MS in 1929 and his PhD in 1932.

REFLECTIONS OF A PHYSICIST
Second Edition, enlarged
by P. W. Bridgman
Philosophical Library **$6**

P. W. Bridgman, Higgins Professor at Harvard and winner of the Nobel Prize in physics for 1946, collected most of his non-technical writings for publication in 1950.

In this second edition of "Reflections of a Physicist," ten new papers have been added to the original collection—and slotted neatly into the various editorial subdivisions which were set up for that collection.

These reflections range over a good many fields, but the essays have one thing in common in that they all reflect Bridgman's now-familiar "operational" approach.

With skill and clarity, Dr. Bridgman brings this experimental attitude to bear, not only on physical concepts, but on such things as the scientist's place in society, cybernetics, politics and the scientific method.


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Here a Sperry Field Engineer checks with an Air Force Observer on the operation of the Sperry K Bombing Navigation System.

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Systems Engineering encompasses difficult advanced design problems of the type which involve interactions, compromises, and a high degree of optimization between portions of complex complete systems, as for example, between the electrical, mechanical, aeronautical, and chemical portions of a system. As an added complication the design of such systems is frequently very closely related to the characteristics of the human beings who will maintain and operate the systems. For the purpose of the Fellowship program, the words "Systems Engineering" are considered to include the techniques and practice of "Operations Research."

The program for each Fellow covers approximately a twelve-month period, part of which is spent at The Ramo-Wooldridge Corporation, and the remainder at the California Institute of Technology or the Massachusetts Institute of Technology working toward the Doctor's degree, or in post-doctoral study. Fellows in good standing may apply for renewal of the Fellowship for a second year.

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THE VALUE OF SCIENCE

by RICHARD P. FEYNMAN

Of all its many values, the greatest must be the freedom to doubt

FROM TIME TO TIME, people suggest to me that scientists ought to give more consideration to social problems—especially that they should be more responsible in considering the impact of science upon society. This same suggestion must be made to many other scientists, and it seems to be generally believed that if the scientists would only look at these very difficult social problems and not spend so much time fooling with the less vital scientific ones, great success would come of it.

It seems to me that we do think about these problems from time to time, but we don't put full-time effort on them—the reason being that we know we don't have any magic formula for solving problems, that social problems are very much harder than scientific ones, and that we usually don't get anywhere when we do think about them.

I believe that a scientist looking at non-scientific problems is just as dumb as the next guy—and when he talks about a non-scientific matter, he will sound as naive as anyone untrained in the matter. Since the question of the value of science is not a scientific subject, this talk is dedicated to proving my point—by example.

The first way in which science is of value is familiar to everyone. It is that scientific knowledge enables us to do all kinds of things and to make all kinds of things. Of course if we make good things, it is not only to the credit of science; it is also to the credit of the moral choice which led us to good work. Scientific knowledge is an enabling power to do either good or bad—but it does not carry instructions on how to use it. Such power has evident value—even though the power may be negated by what one does.

I learned a way of expressing this common human problem on a trip to Honolulu. In a Buddhist temple there, the man in charge explained a little bit about the Buddhist religion for tourists, and then ended his talk by telling them he had something to say to them that they would *never* forget—and I have never forgotten it. It was a proverb of the Buddhist religion:

"To every man is given the key to the gates of heaven; the same key opens the gates of hell."

What then, is the value of the key to heaven? It is true that if we lack clear instructions that determine which is the gate to heaven and which the gate to hell, the key may be a dangerous object to use, but it obviously has value. How can we enter heaven without it?

The instructions, also, would be of no value without the key. So it is evident that, in spite of the fact that science could produce enormous horror in the world, it is of value because it *can* produce *something.*

Another value of science is the fun called intellectual enjoyment which some people get from reading and learning and thinking about it, and which others get from working in it. This is a very real and important point and one which is not considered enough by those who tell us it is our social responsibility to reflect on the impact of science on society.

Is this mere personal enjoyment of value to society as a whole? No! But it is also a responsibility to consider the value of society itself. Is it, in the last analysis, to arrange things so that people can enjoy things? If so, the enjoyment of science is as important as anything else.

But I would like *not* to underestimate the value of the world view which is the result of scientific effort. We have been led to imagine all sorts of things infinitely more marvelous than the imaginings of poets and dreamers of the past. It shows that the imagination of nature is far, far greater than the imagination of

"The Value of Science" was given as a public address at the 1955 autumn meeting of the National Academy of Sciences, held on the Caltech campus November 2, 3 and 4.

man. For instance, how much more remarkable it is for us all to be stuck—half of us upside down—by a mysterious attraction, to a spinning ball that has been swinging in space for billions of years, than to be carried on the back of an elephant supported on a tortoise swimming in a bottomless sea.

I have thought about these things so many times alone that I hope you will excuse me if I remind you of some thoughts that I am sure you have all had—or this type of thought—which no one could ever have had in the past, because people then didn't have the information we have about the world today.

For instance, I stand at the seashore, alone, and start to think. There are the rushing waves . . . mountains of molecules, each stupidly minding its own business . . . trillions apart . . . yet forming white surf in unison.

Ages on ages . . . before any eyes could see . . . year after year . . . thunderously pounding the shore as now. For whom, for what? . . . on a dead planet, with no life to entertain.

Never at rest . . . tortured by energy . . . wasted prodigiously by the sun . . . poured into space. A mite makes the sea roar.

Deep in the sea, all molecules repeat the patterns of one another till complex new ones are formed. They make others like themselves . . . and a new dance starts.

Growing in size and complexity . . . living things, masses of atoms, DNA, protein . . . dancing a pattern ever more intricate.

Out of the cradle onto the dry land . . . here it is standing . . . atoms with consciousness . . . matter with curiosity.

Stands at the sea . . . wonders at wondering . . . I . . . a universe of atoms . . . an atom in the universe.

The grand adventure

The same thrill, the same awe and mystery, come again and again when we look at any problem deeply enough. With more knowledge comes deeper, more wonderful mystery, luring one on to penetrate deeper still. Never concerned that the answer may prove disappointing, but with pleasure and confidence we turn over each new stone to find unimagined strangeness leading on to more wonderful questions and mysteries—certainly a grand adventure!

It is true that few unscientific people have this particular type of religious experience. Our poets do not write about it; our artists do not try to portray this remarkable thing. I don't know why. Is nobody inspired by our present picture of the universe? The value of science remains unsung by singers, so you are reduced to hearing—not a song or poem, but an evening lecture about it. This is not yet a scientific age.

Perhaps one of the reasons is that you have to know how to read the music. For instance, the scientific article says, perhaps, something like this: "The radioactive phosphorous content of the cerebrum of the rat decreases to one-half in a period of two weeks." Now what does that mean?

It means that phosphorus that is in the brain of a rat (and also in mine, and yours) is not the same phosphorus as it was two weeks ago, but that all of the atoms that are in the brain are being replaced, and the ones that were there before have gone away.

So what is this mind, what are these atoms with consciousness? Last week's potatoes! That is what now can *remember* what was going on in my mind a year ago—a mind which has long ago been replaced.

That is what it means when one discovers how long it takes for the atoms of the brain to be replaced by other atoms, to note that the thing which I call my individuality is only a pattern or dance. The atoms come into my brain, dance a dance, then go out; always new atoms but always doing the same dance, remembering what the dance was yesterday.

The remarkable idea

When we read about this in the newspaper, it says, "The scientist says that this discovery may have importance in the cure of cancer." The paper is only interested in the use of the idea, not the idea itself. Hardly anyone can understand the importance of an idea, it is so remarkable. Except that, possibly, some children catch on. And when a child catches on to an idea like that, we have a scientist. These ideas do filter down (in spite of all the conversation about TV replacing thinking), and lots of kids get the spirit—and when they have the spirit you have a scientist. It's too late for them to get the spirit when they are in our universities, so we must attempt to explain these ideas to children.

I would now like to turn to a third value that science has. It is a little more indirect, but not much. The scientist has a lot of experience with ignorance and doubt and uncertainty, and this experience is of very great importance, I think. When a scientist doesn't know the answer to a problem, he is ignorant. When he has a hunch as to what the result is, he is uncertain. And when he is pretty darn sure of what the result is going to be, he is in some doubt. We have found it of paramount importance that in order to progress we must recognize the ignorance and leave room for doubt. Scientific knowledge is a body of statements of varying degrees of certainty—some most unsure, some nearly sure, none *absolutely* certain.

Now, we scientists are used to this, and we take it for granted that it is perfectly consistent to be unsure—that it is possible to live and *not* know. But I don't know whether everyone realizes that this is true. Our freedom to doubt was born of a struggle against authority in the early days of science. It was a very deep and strong struggle. Permit us to question—to doubt, that's all—not to be sure. And I think it is important that we do not forget the import-

ance of this struggle and thus perhaps lose what we have gained. Here lies a responsibility to society.

We are all sad when we think of the wondrous potentialities human beings seem to have, as contrasted with their small accomplishments. Again and again people have thought that we could do much better. They of the past saw in the nightmare of their times a dream for the future. We, of their future, see that their dreams, in certain ways surpassed, have in many ways remained dreams. The hopes for the future today are, in good share, those of yesterday.

Education, for good and evil

Once some thought that the possibilities people had were not developed because most of these people were ignorant. With education universal, could all men be Voltaires? Bad can be taught at least as efficiently as good. Education is a strong force, but for either good or evil.

Communications between nations must promote understanding: so went another dream. But the machines of communication can be channeled or choked. What is communicated can be truth or lie. Communication is a strong force also, but for either good or bad.

The applied sciences should free men of material problems at least. Medicine controls diseases. And the record here seems all to the good. Yet there are men patiently working to create great plagues and poisons. They are to be used in warfare tomorrow.

Nearly everybody dislikes war. Our dream today is peace. In peace, man can develop best the enormous possibilities he seems to have. But maybe future men will find that peace, too, can be good and bad. Perhaps peaceful men will drink out of boredom. Then perhaps drink will become the great problem which seems to keep man from getting all he thinks he should out of his abilities.

Clearly, peace is a great force, as is sobriety, as are material power, communication, education, honesty and the ideals of many dreamers.

We have more of these forces to control than did the ancients. And maybe we are doing a little better than most of them could do. But what we ought to be able to do seems gigantic compared with our confused accomplishments.

Why is this? Why can't we conquer ourselves?

Because we find that even great forces and abilities do not seem to carry with them clear instructions on how to use them. As an example, the great accumulation of understanding as to how the physical world behaves only convinces one that this behavior seems to have a kind of meaninglessness. The sciences do not directly teach good and bad.

Through all ages men have tried to fathom the meaning of life. They have realized that if some direction or meaning could be given to our actions, great human forces would be unleashed. So, very many answers have been given to the question of the meaning of it all. But they have been of all different sorts, and the proponents of one answer have looked with horror at the actions of the believers in another. Horror, because from a disagreeing point of view all the great potentialities of the race were being channeled into a false and confining blind alley. In fact, it is from the history of the enormous monstrosities created by false belief that philosophers have realized the apparently infinite and wondrous capacities of human beings. The dream is to find the open channel.

What, then, is the meaning of it all? What can we say to dispel the mystery of existence?

If we take everything into account, not only what the ancients knew, but all of what we know today that they didn't know, then I think that we must frankly admit that *we do not know*.

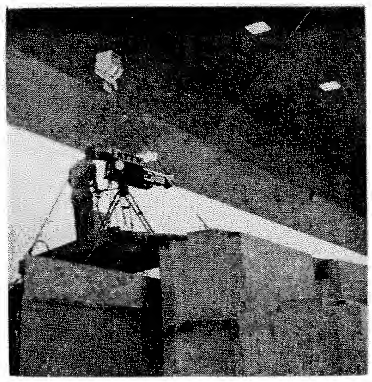
But, in admitting this, we have probably found the open channel.

This is not a new idea; this is the idea of the age of reason. This is the philosophy that guided the men who made the democracy that we live under. The idea that no one really knew how to run a government led to the idea that we should arrange a system by which new ideas could be developed, tried out, tossed out, more new ideas brought in; a trial and error system. This method was a result of the fact that science was already showing itself to be a successful venture at the end of the 18th century. Even then it was clear to socially-minded people that the openness of the possibilities was an opportunity, and that doubt and discussion were essential to progress into the unknown. If we want to solve a problem that we have never solved before, we must leave the door to the unknown ajar.

Our responsibility as scientists

We are at the very beginning of time for the human race. It is not unreasonable that we grapple with problems. There are tens of thousands of years in the future. Our responsibility is to do what we can, learn what we can, improve the solutions and pass them on. It is our responsibility to leave the men of the future a free hand. In the impetuous youth of humanity, we can make grave errors that can stunt our growth for a long time. This we will do if we say we have the answers now, so young and ignorant; if we suppress all discussion, all criticism, saying, "This is it, boys, man is saved!" and thus doom man for a long time to the chains of authority, confined to the limits of our present imagination. It has been done so many times before.

It is our responsibility as scientists, knowing the great progress and great value of a satisfactory philosophy of ignorance, the great progress that is the fruit of freedom of thought, to proclaim the value of this freedom, to teach how doubt is not to be feared but welcomed and discussed, and to demand this freedom as our duty to all coming generations.



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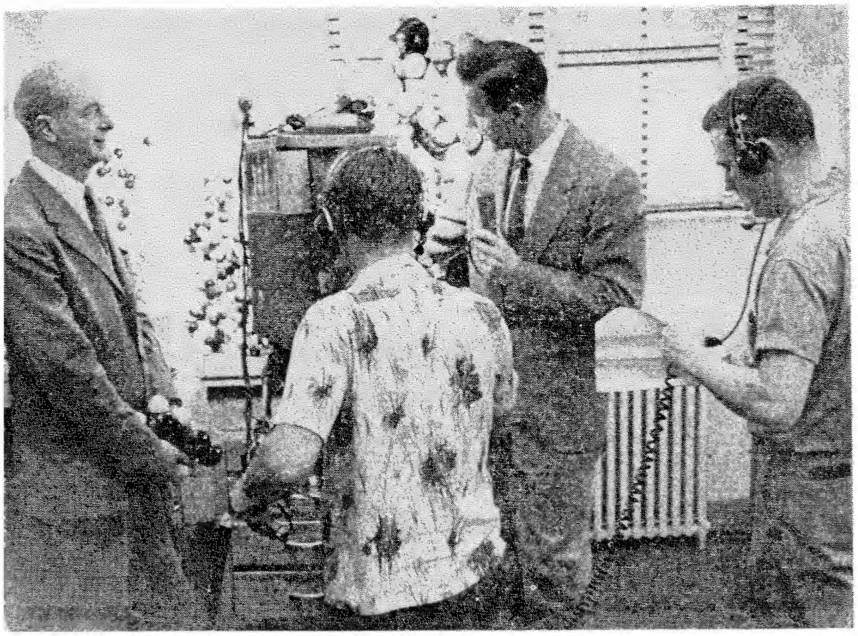
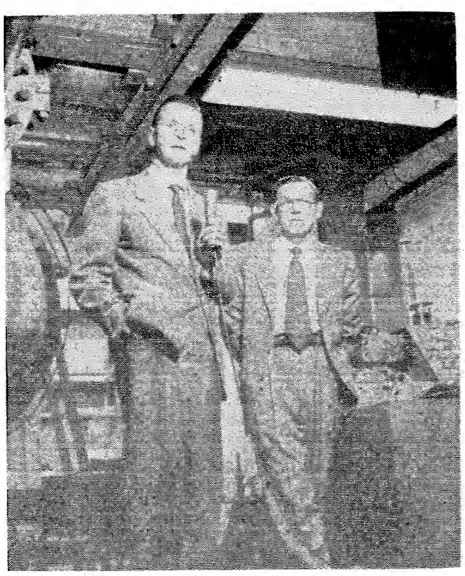
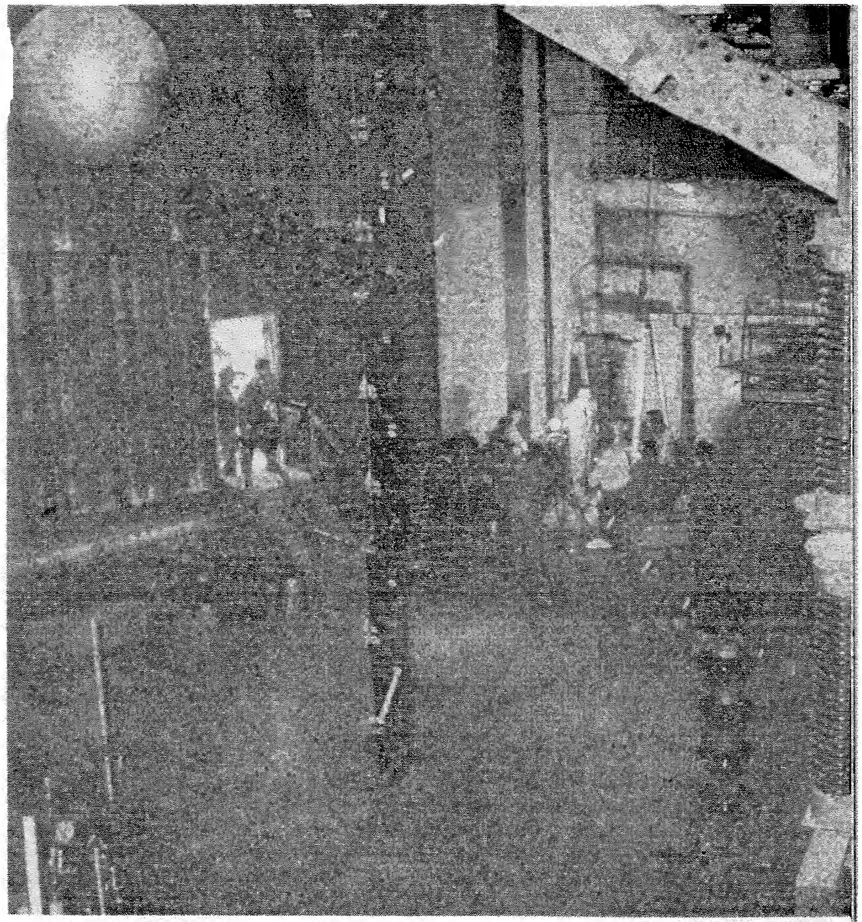


TV TOOK A WHIRLWIND TOUR of the Caltech campus last month and covered the ground in 30 minutes, less commercials, on the Richfield Oil Corporation's "Success Story" program. Some of the highlights of the tour are shown on these pages.

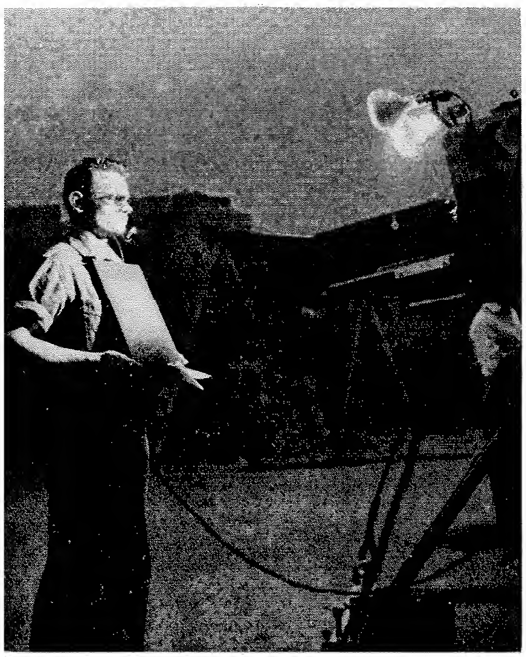
Dr. Linus Pauling (left), chairman of the Division of Chemistry and Chemical Engineering, demonstrated and described some of his molecular models. Dr. Milton Plesset (waiting for his cue in the picture at lower left), professor of applied mechanics, ran a cavitation test in the Hydrodynamics Laboratory. And the million-volt synchrotron sat for its portrait (below).



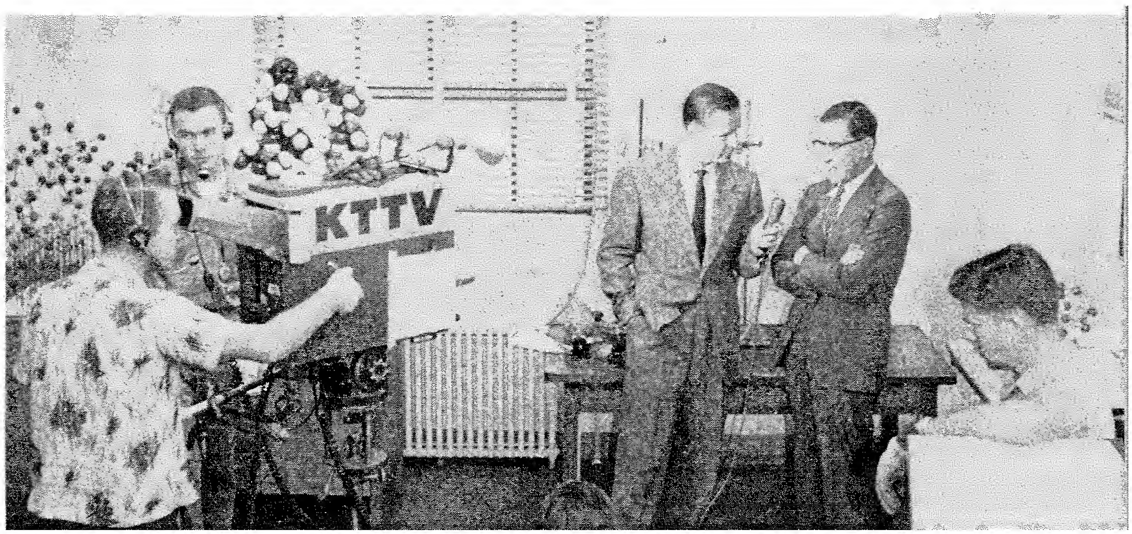
Around the campus in 30 minutes



Workers in the High Voltage Laboratory prepare to produce some artificial lightning



TV cameras move in for a close-up of a Palomar photograph



Dr. A. J. Haagen-Smit describes some of the effects of smog

THE AIR POLLUTION PROBLEM

by L. A. DuBRIDGE

ONE OF OUR BIGGEST HANDICAPS in the fight for clean air in Los Angeles has been the fact that our air pollution is called "smog." The term "smog" originated in certain midwestern and eastern cities where —twenty years or more ago—on damp, foggy winter days a black pall of soft-coal smoke settled over the city, blanking out the sun and literally turning day into night. Those black, sulfurous clouds were a mixture of coal smoke and fog, and the name "smog" was a natural one.

The cure for that kind of smog, although it was not easy, was obvious—namely, stop the smoke! That is, stop burning soft coal or else put in smoke eliminators. And so in St. Louis, Pittsburgh and other cities the factories put in eliminators and better combustion controls; the apartment houses and private homes switched from soft coal to hard coal or to oil or gas. And presto! The smog stopped!

But Los Angeles begins where Pittsburgh and St. Louis left off. We have not burned soft coal here for fifty years. Our worst smoggy days are like bright, clear sunshine compared to a good old-fashioned St. Louis smog. Even today there is plenty of air pollution in every major city in the nation.

The Los Angeles air pollution problem is more serious than some, not because we are "dirtier" than other cities, but only because Mother Nature, in providing us such a nice climate, failed to provide southern California with adequate ventilation. Hence, we must be much cleaner than anyone else needs to be.

Because old-fashioned eastern smog was largely caused by one thing—namely, soft coal—we in the West also, at first, looked for a simple single cause for our trouble. In 1942-45 everyone was sure that the wartime synthetic rubber plants were the major culprit. Possibly, then, they were. But by 1945 they were cleaned up or shut down, yet the air pollution persisted. Then we went after sulfur. Expensive equipment was built to remove sulfur from the stack gases of refineries and other industrial plants. This too was probably a good thing to do, but the pollution problem persisted. Nor did the elimination of many of the principal sources of visible smoke and fumes solve the problem.

Finally, the time came when a few people realized that we had a really tough problem on our hands in Los Angeles and that someone had better do some good solid research to find out just what *were* the objectionable pollutants in Los Angeles air and where they were coming from.

Eight years ago the newly organized Air Pollution Control District began its research program. About the same time the oil industry—the most frequently blamed culprit—started more research. Two years ago the Air Pollution Foundation began an independent research program, and today a very substantial attack on the problem is under way in many laboratories. Nevertheless, we are still not spending half as much as we should on research. We are still trying to solve a billion-dollar problem with peanuts!

The very first results of this research revealed the complexity of the problem. It soon became evident that there were *many* components of air pollution—and that some of them at least had no relation at all to visible smoke. They came from invisible vapors of unburned gasoline and other petroleum products. But these invisible and supposedly innocent vapors, once trapped under the southern California inversion layer, went through a chemical change—a complex series of changes, in fact—in which one essential contributor was (of all things) our good friend, California sunshine! It was found that smoggy air contains peroxides of these gasoline and other organic substances. It also contains ozone and nitrogen oxides, in addition to the usual smoke and dust of a metropolitan area.

Air pollution in Los Angeles is thus many things—many things going into the atmosphere and there reacting with each other and with the air itself, and with sunshine, in complex ways. The cities of the East today face this same problem—that is, "oil smog" has replaced "coal smog." The cleanliness of the air in various

Some plain words about smog—what it is, where it comes from, who's to blame and what we can do about it—by the new chairman of the Board of the Air Pollution Foundation

communities at various times is mostly a matter of how good is the ventilation.

Clearly, there was a whole series of new questions to be answered about this new kind of smog. First we must ask what are the most objectionable effects of air pollution. Eye irritation? Bad smell? Bad taste? Low visibility? Rubber cracking? What causes each of these? Are many compounds involved? Or only a few? Or only one? Through which chemical reactions are the harmful materials produced? From what raw materials? What catalysts, if any, participate in the reactions? Can *they* be controlled? How? How much will it cost to reduce the emission of various materials? To what levels *can* each be reduced? To what levels must it be reduced to make our air tolerably clean?

These are questions whose answers were *all unknown* a few years ago. Indeed we did not know enough *then* even to *ask* some of them. Many of the answers are unknown today. But today every one of these questions is under intensive study; some can now be answered. That is itself tremendous progress.

Let us turn first to the question, "What are the objectionable effects of air pollution?" It is not difficult to prepare a list. The principal items are (1) reduced visibility, (2) eye irritation, (3) damage to plants, (4) the cracking of rubber, (5) a pungent odor, (6) a general physical discomfort on the part of many people who are especially sensitive. In addition, there may be longer-term health effects which we do not understand, but no specific hazard attributable to air pollution has yet been established.

Now if one stops to think about it, it is rather amazing that there are so many diverse effects produced by impure air. One can think of many things in the air which would cause reduced visibility but which would not have a bad smell, which would not crack rubber, damage plants, or produce eye irritation. Conversely, there are many things which could produce a bad smell and eye irritation which would not reduce visibility. Yet our general observation is that all these effects are observed together on smoggy days. The first question which arises, therefore, is whether all of these effects are due to a single substance or whether they are due to several substances which happen to appear together.

In the last two years careful measurements have shown that actually the degree of eye irritation, of visibility reduction and of plant damage do not, in fact, all rise and fall together. On some days, or on certain hours of a single day, the relative intensity of these phenomena may very considerably. An obvious example is when a dense sea fog rolls in and mixes with the man-made smog. On such days the visibility becomes very low indeed, although the smell and eye irritation may not be too objectionable. It now seems clear that the different objectionable results of smog are produced by several different contaminants in the atmosphere—not all by a single substance.

If this is the case, one might think that the next step would be to determine all the foreign substances in the air and then find out which ones produce which effects. This is not so easy as it sounds for there are literally hundreds of compounds and materials present in our atmosphere, mostly in very tiny quantities, many of them far below any possibility of noticeable effects. At the same time, one of the grave difficulties of the air pollution problem is that certain substances need be present only to the extent of a few parts in one hundred million in order to have detectable or even objectionable effects. In fact, the identification and measurement of such tiny concentrations of material is, in itself, a great achievement in analytical chemistry. Newly developed instruments are now automatically recording, day and night, the concentrations of some of these materials.

Today we have a pretty fair picture of the pollutants in the air which seem to be causing the principal objectionable characteristics of smog.

In the first place, we find particulate matter—that is, finely divided solid particles of smoke, ashes, dust, and similar substances, plus tiny liquid droplets, both of

water and of different kinds of organic substances.

We then find an array of gaseous compounds, particularly the following: (1) vapors of gasoline and oil (known chemically as hydrocarbon vapors); (2) nitrogen compounds, particularly nitrogen oxides (formed principally in combustion processes from the nitrogen in ordinary air); (3) ozone (a compound whose molecules consist of three oxygen atoms, whereas the ordinary oxygen in our atmosphere has two oxygen atoms per molecule); (4) oxides of hydrocarbons (that is, gasoline and oil molecules to which one or more atoms of oxygen have been attached); and (5) sulfur compounds, especially sulfur oxides (formed principally in the burning of fuels which contain small quantities of sulfur).

If we consider the particulate matter first, we quickly recognize that it is the principal factor in the reduction of visibility. Reduced visibility is caused by the scattering of light from tiny individual solid or liquid particles suspended in the atmosphere. It is not caused by gaseous materials. These particles can consist either of actual solid particles, as of smoke or dust; or of liquid droplets as in the case of a fog; or of liquid droplets condensed on solid particles.

The solid particulate matter is easiest to see and to control. Clouds of smoke or dust coming from industrial plants or from backyard incinerators are readily detectable. The Los Angeles Air Pollution Control District has made giant strides in reducing the amount of smoke and dust being emitted by industrial plants, and it will not be long before solid particulate matter from this source will be reduced to a fraction of what it was a few years ago. For many plants, the combustion right now is just about as clean as engineering science knows how to make it. And yet that is not good enough! More research to develop techniques of smoke reduction is needed.

Backyard incinerators

The Air Pollution Control District has also taken important steps toward the elimination of the backyard incinerator which remains today as the most important source of solid particulate matter in our atmosphere. Throwing smoke, ashes and dust into the air from a million and a half backyard incinerators is a dirty, filthy custom and it should have been stopped long ago. I am not saying that the incinerators are the *sole* cause of air pollution, but they do project over a hundred tons of "dirt" into the atmosphere each day and when this is eliminated we will have purer, cleaner air in the Los Angeles basin.

To reduce the smoggy haze caused by tiny droplets of organic materials is not so easy. Clearly, we must control the sources of these organic materials. Some of these materials are emitted originally as gases or vapors, but later are transformed into liquid droplets.

This brings us to the gaseous components of polluted air. As a result of work in many scientific laboratories in the past few years, it appears now that the principal offensive gases in our atmosphere are oxides of hydrocarbons, oxides of nitrogen and ozone. Though these are not the only atmospheric pollutants, they seem to be the ones principally responsible for eye irritation, for plant damage and for the cracking of rubber. Where do these gaseous compounds come from?

Nitrogen oxide, whose role in the air pollution problem was almost unrecognized a few years ago, is produced in nearly every combustion process. Wherever oil, gas, coal, wood, trash, or anything else is being burned, some of the nitrogen in the air is combined with oxygen to form nitrogen oxides. The nitrogen oxides are gases which are quite invisible and, therefore, not all the sources can necessarily be located by going around looking for smoke clouds. In fact, it is unfortunately necessary to report that no way of reducing the emission of nitrogen oxides into our atmosphere has yet been invented. Since combustion is the basis of any industrial society, since combustion occurs in every home, apartment building, power plant and factory, it is clear that strenuous efforts to develop methods of reducing the emission of nitrogen oxides are called for.

Oxides of hydrocarbons

The situation is somewhat similar in the case of the oxides of hydrocarbons. It is these substances which are the principal causes of eye irritation and plant damage. These hydrocarbon oxides are formed in the atmosphere itself where unburned hydrocarbons, in the presence of sunshine and nitric oxide, combine with the oxygen of the air. Since, obviously, we in southern California can't eliminate either sunshine or air, the only way of reducing the oxides of hydrocarbons is to reduce the emission of hydrocarbons and nitric oxide.

Now hydrocarbon vapors—that is, vapors of gasoline, oil and other organic materials—are also normally quite invisible. Hence, again, the sources of these vapors cannot be observed by visual means. We do know, however, that any process involving the burning of gasoline, oil, natural gas or other petroleum products results in the emission into the air of a certain percentage of unburned vapors. In addition, wherever volatile gasoline or other petroleum products are exposed to the air (as in storage tanks or filling stations) there is a certain amount of evaporation into the air.

It is to find methods of reducing the emission of these hydrocarbons into the atmosphere that the most strenuous efforts, both in research and in enforcement, are now focused. The problem is a terribly difficult and complex one. We can say, however, that industry in recent years has taken important strides in reducing the escape of hydrocarbon vapors from its plants. To reduce the contribution of the automobile is the next stage of the problem.

The third objectionable impurity in the air which I have mentioned is ozone. Ozone is not produced in combustion processes at all, but is formed entirely in

the atmosphere from air and sunshine with the catalytic assistance of nitrogen oxides, hydrocarbons or other organic materials. We know that clean, pure desert air at sea level contains no appreciable quantities of ozone. On a smoggy day in Los Angeles, however, ozone occurs in amounts ranging up to six- or eight-tenths of a part per million.

It seems clear that ozone is the principal contributor to the cracking of rubber. *Yet no person or company is guilty of putting ozone into the air!* Naturally, therefore, the Air Pollution Control District faces a dilemma. Ozone is a bad air contaminant, but nobody is contaminating the air with ozone. Like the hydrocarbon peroxides, it is a compound formed in the atmosphere as a result of the action of sunshine plus oxygen plus some other impurities.

Several years ago it was shown in laboratory experiments (by Dr. Haagen-Smit of Caltech) that hydrocarbon vapors plus nitrogen oxides plus light will form ozone and peroxides. It is now clear that the major problem is to find ways of reducing the amount of these substances which enter our atmosphere. But these substances are found in every combustion process. And we can't stop combustion and still have an industrial community.

Does this mean that the problem is a hopeless one? Certainly not! It does, however, mean that the problem is not going to be solved next week by pushing a button or by putting somebody in jail, or firing somebody from his job, or even by holding mass meetings of indignant citizens. What are the ways by which the pollution nuisance will be reduced?

Change of climate

First, let us dispose of one class of remedies which keep cropping up; namely, those which involve changing the climate of the Los Angeles area or producing better ventilation. All such schemes, involving blowers or fans or heaters or smokestacks, can be seen in perspective if we remember simply that the total mass of the air which lies over the Los Angeles basin between sea level and about 500 feet is approximately one-quarter of a billion tons. In other words, the weight of the air which we have to deal with is twice the weight of all the steel produced in the United States in a whole year.

Now if we had 250 million tons of steel sitting in downtown Los Angeles and we had to transport it 50 miles out into the desert twice a day, we would recognize that we had quite a job on our hands. A quarter billion tons of steel, incidentally, would be a pile 1000 feet long, 1000 feet wide and 1000 feet high. Moving this steel would actually be easier than moving air, because at least you could load it on freight cars and haul it away! But to move the air in the Los Angeles basin rapidly enough to change it, say, twice a day would require more power (whether it be in the form of heat, electricity, sunshine or gasoline engines) than all the electric power generated in the United States.

In other words, we are not going to get rid of the Los Angeles smog by blowing it away! What should we do?

First we need more research. We cannot eliminate combustion itself, but we can find ways to make combustion more complete so that smoke and unburned hydrocarbon vapors do not escape. If smoke and hydrocarbons were *completely* burned, the products would be simply water vapor and carbon dioxide which are quite harmless.

In larger power plants the combustion is already quite complete. Industrial companies are very anxious to prevent valuable unburned fuel from escaping up the stacks. But some smoke does escape and a considerable quantity of nitrogen oxide escapes. It is very important to find ways of converting these nitrogen oxides back to nitrogen and oxygen before they escape. There is, doubtless, some catalytic process which will do this, but no practical method has been found.

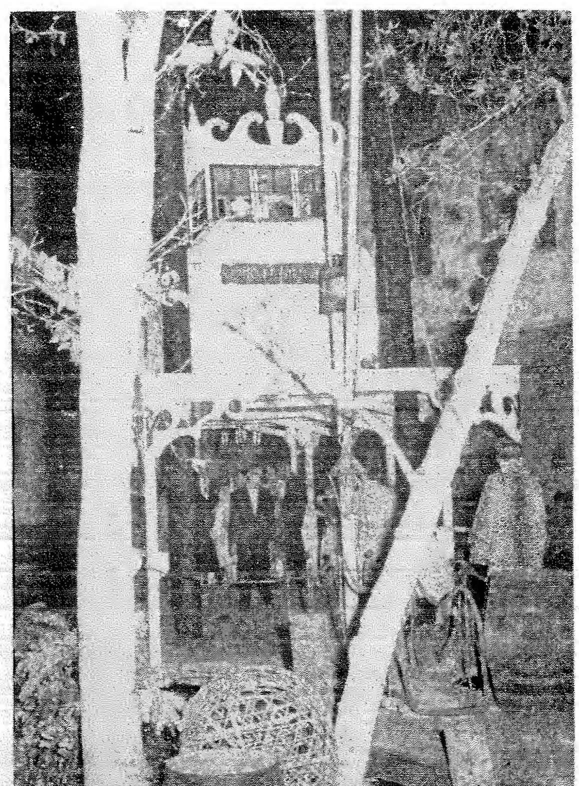
The principal source of smog

The two million automobiles of Los Angeles are pumping into the air 1200 tons of unburned gasoline plus 300 tons of nitrogen oxide each day. This is four times as much hydrocarbon as comes from industrial sources and is 50 percent more nitrogen oxide. The laboratories of the automobile industry are working hard on methods to improve the combustion of the gasoline. No satisfactory device for this purpose has, however, yet been produced, and there is certainly a year or more of development and test work still ahead before one can be adopted and placed on the market. A nitrogen oxide eliminator is still further away. No one knows how much either device will cost. Certainly the total job of equipping two million cars will take both time and money. The thing to remember is that you and I and the other two million car owners are the principal source of smog—and we are going to have to pay to get it eliminated. Still worse, we are going to have to wait patiently until the engineering research required to develop the necessary devices has been completed.

In the meantime, we can do three things: (1) Eliminate the backyard incinerators which produce many hundreds of tons of smoke, dirt, organic materials and nitrogen oxides; (2) support the research programs of the Air Pollution Foundation which are seeking to find new methods of reducing air pollution; (3) support the Air Pollution Control District in both its research and enforcement activities.

Finally, we can cease quarreling among ourselves about who causes the most smog. We all cause smog, and not until we all stop our contribution will our air be tolerably clean. It cost 3/4 of a billion dollars to get an adequate supply of pure water in southern California. We should be willing to pay as much for pure air.

In Dabney's Dreamland—electronically synchronized fountains cascade in a setting of filtered light.



In Blacker's courtyard—a showboat (the Vernon L. Sturnferst) rides at anchor in a man-made river.

THE BIG BASH

"HEY, I need two coolies," a voice bawled out—but the Techman took it as an invitation to hide behind the paint brush he was daubing with. A thing possessed had descended upon the troops. A pressing deadline had concentrated a week's work into a day's. Even Snakes had become aware that commotion made study difficult. Self-appointed Legrees were tossing work to anyone not moving. Nothing like the old communal atmosphere.

The Techman wondered if Marx would have approved the dance as good training. He began to appreciate the fallacies of communist philosophy.

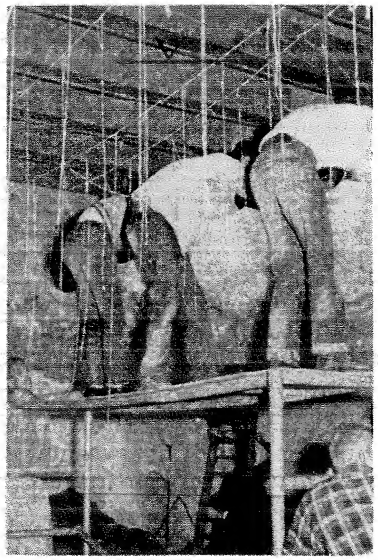
"This thing's so great I think I'll get a date for it," his paintbucket partner interrupted. No comment. That was a real "guts play" from a guy who hadn't had a date since the last Interhouse.

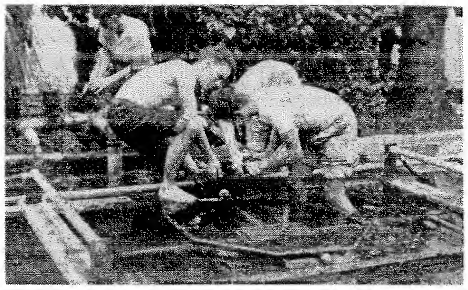
"Bet it rains tonight," one of the sunny-side-up boys interjected. He was put down by silence. The Interhouse Dance was Tech's principal claim to fame in the social realm and everyone knew damn well it couldn't rain. When completed it would reveal how futile similar attempts of all other schools were. As a onetime fraternity man he wasn't completely convinced of this, but believing made the work less irritating.

He had to admit that if ingenuity could make a dance, the prophecy would be fulfilled. Talent and drive not often tapped was being shoved into the sunshine of the courtyard and it was good. He wondered how these guys managed to hide themselves so well during the rest of the year. Both money and energy were being expended prodigally. A gentleman's agreement had set a limit of $500 per house. It was a well-meant but impossible gesture. A pre-dance estimate from one house had totaled $950. This was madness, thought the Techman. So had they; they pared it to $600.

A shower, a meal and a look to see what classes had been missed last week, then back to the brainchild. With all the purpose and diligence of Noah, the troops were striving to catch lost time. There was an unrelenting clamor from seven to four a.m., the whir of buzz-saws and collisions of hammers. The Techman had serious misgivings about his choice of a courtyard room.

Last minute scenery additions rounded the atmosphere while the Techman dragged himself to pick up his woman. Pre-parties filled the alleys with shuttling guests.





With coolie labor, a week's work can be concentrated into a day's.

Curiosity soon prodded the Techman and date to other houses. His pride assured him that nothing could withstand critical comparison with his house's creation.

Early arrivals had chanced wet paint and stray tools, but by nine o'clock all was clear. Dance music shaded from Guy Lombardo to progressive. Fountains spewed refreshments and it was "elbows in" dancing throughout the evening. Where all the people had come from he wasn't quite sure; maybe some were those 300 instructors who were reputed to be at Tech for his benefit.

With churning paddlewheel and a whistle to strike envy into any locomotive, the original "Showboat" spanned the lake that once was Blacker's courtyard. He knew the whistle worked; the boys finished installing

The size of the crowd proves that the Interhouse is still Tech's principal claim to fame in the social realm.

it last night and its testing had jerked him from his coma like a bucket of ice water.

In the room perspective had been distorted; he began to feel Dabney's "Dreamland." He was pleasantly lost for a moment. Outside, electronically synchronized fountains cascaded in a setting of filtered light.

As a newly-caged animal eventually settles into the luxury of captivity, so the milling throng became familiar with the spectacle and the air relaxed.

The sunken hull of Verne's *Nautilus* guarded the olive walk entrance to Throop Club. Above dancing couples, undulating tentacles seemed to keep half-time to the cool music. Buddha teleported his likeness to approve the Chinese garden that was Ricketts. All was theme. Moat, drawbridge and dungeons marked Fleming's medieval castle. Suits of armor lined the wall. A coffin of nails reminded his fatigue that it was past midnight and he should sleep.

Money's worth

It was a peaceful day like one after exams. The campus was an oasis of tranquility between California and San Pasqual streets. The Techman smoked himself to his next class. It was sparsely settled; guys who lived far away had left early for the Thanksgiving holiday. This was the last class of the day and he was anxious to be on the road too. He would have hated to miss class for the simple reason that then he wouldn't be getting his money's worth. In this respect he was a campus anomaly.

The instructor's back followed the all-knowing chalk across the blackboard. He was mumbling every third symbol and arriving at the result it had taken the Techman two hours to achieve the night before. The instructor finally broke from the board with, "So you see there's nothing conceptually new in this problem: just draw the free-body diagram."

I'll bet this guy was conceived through a free-body diagram, thought the Techman. The bell rang like a reprieve, signalling the end of his money's worth.

It was still a beautiful day, but tomorrow would be better, even if it rained—Thanksgiving and all the trimmings. One of the most valuable courses offered on campus, he mused, was "How to Appreciate Your Mother's Cooking," proctored by the student house kitchens. Yes sir. Turkey, Thanksgiving and all the trimmings.

It was the best to be home, home with the old folks and the guys he had grown up with. It was almost tradition now for the old gang to get together over the holiday.

"Hi, St. George, how's life in the monastery? You sure look thin, what do they feed you up there besides books?"

"Oh, we get smog and student house food."

The Techman was on the defensive; it was all right for him to criticize, but let someone else take a verbal poke at Tech and his jaw jutted. It irritated the hell out of him to see the "wiser-in-the-ways-of-the-world" smirks on the faces of his old liberal arts buddies. He tried to dismiss it as the compensation of clods who mistook rumors and appearances for facts.

Something had happened to him since he'd been at Tech that he knew could have happened few other places. It was probably the living and associating with people of broader and richer philosophies than those of most of the college men he had known elsewhere. Maybe there was even a touch of the religious in it; he wasn't sure. Whatever it was was worth all the booze parties in the world. This he knew and felt, and there were few things he both knew and felt. Not that he had anything against "living," but he knew it existed at Tech as a diversion, not as an end or even a means.

He had better not let the stuff they had put under his skin show through or these guys would never lay off.

I'll just play along, he decided.

"How do you boys like fraternity life?" the Techman queried.

"It's great for the social life. How do you guys up there study without social life?"

"What do you mean? We have plenty of social life at Tech. We have exchanges and dances and Throop Club Stags and even election rallies with beer for those over 21 and root beer for those under."

"Gee whiz, we didn't realize you fellas had such a raucous existence. Where do you keep your women?"

"Oh, we can take them up to the rooms until 10:30 on week nights or 12:30 on weekends and sometimes till 1:00 on big dance nights like the Interhouse."

"Why do they set an arbitrary time like 10:30? That doesn't sound scientific to me."

"I guess they figure if time is called at 10:30, the girl has a fighting chance," he answered sarcastically.

Rough life

"What kind of beer you drinking now, St. George? You a Coors man yet?"

"No. I don't get much beer at Tech. Beer is strictly taboo, say the rules."

"How do you study?"

"Oh, we manage," he replied with consummate modesty.

"Boy, what a rough life you guys must lead. No beer. They even get beer in the Army."

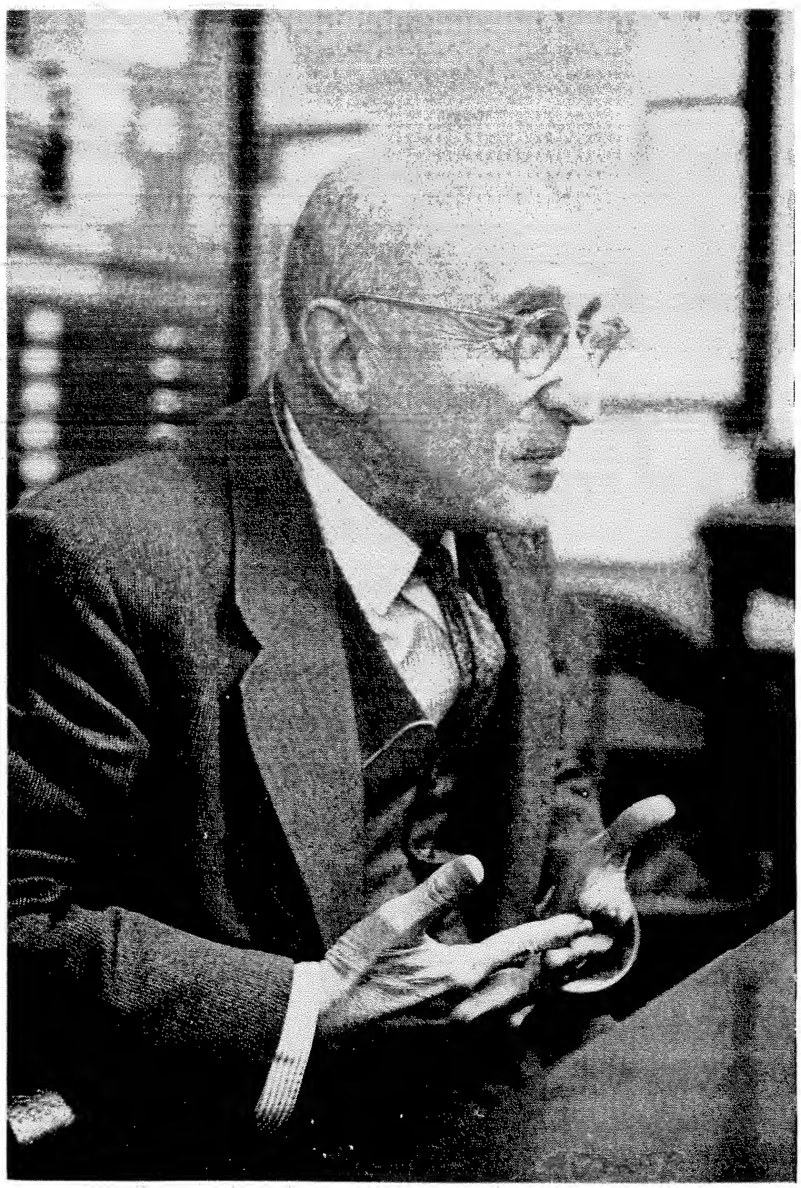
"I know, but would I join to get it?"

Beer taboo? He couldn't remember anyone being on probation for liquor.

"Why don't you have a beer with us?" his host invited.

"OK. I'll try one of your 'Coors'," accepted the Techman. Sitting in the sun, nipping the beer, he felt at home. He sure wished he'd brought a book; the beer didn't taste quite right without one.

—*Tom Dodge '57*



BENO GUTENBERG

Geophysicist

BENO GUTENBERG has been on the staff of Caltech's Seismological Laboratory for 25 years. For 8 years he has been director of the Laboratory, which was set up to study the size, location, occurrence and cause of earthquakes in the world in general and on the Pacific Coast in particular. Many of the advances in this work have either been accomplished or inspired by Dr. Gutenberg, and, because of his important basic researches and discoveries, the ultimate goal of earthquake prediction is a good deal nearer.

As a man who has spent much of his professional life in the study of earthquakes, it is fitting that the most famous story about Beno Gutenberg should center around a quake.

When Einstein was visiting Caltech in 1933 he asked Gutenberg if he could someday give him a short review of earthquake research. So, one Friday afternoon, after Einstein had given a physics lecture, the two men started across the campus to the Athenaeum, where Einstein was staying, while Gutenberg explained some of the phenomena connected with earthquakes.

On their walk they noticed, but ignored the fact, that people seemed to be acting in a rather peculiar manner —dashing across their path and shouting to each other —but their discussion continued uninterrupted until they met Professor Richard Tolman, waiting for them on the Athenaeum steps.

"Well," he said, "now you've had first-hand experience with an earthquake."

And that was the first they knew that they had just

that minute walked blithely through the disastrous Long Beach earthquake.

Mrs. Einstein had the last word on the affair when she met Mrs. Gutenberg on the street next day.

"What do you think of our two dumbbells?" she said.

Beno Gutenberg was born in 1889 in Darmstadt, Germany, where his father owned a soap factory. Beno was the eldest son, but he had no interest in the family business; he was going to be a high school teacher of physics and mathematics.

At the University of Goettingen he took his first courses in geophysics, a subject which at that time included seismology, meteorology, some oceanography, the earth's magnetism and the structure of the earth. As a science, geophysics was then so young that after two years of study Beno was told that he had now learned all there was to know in the field, so he was accordingly qualified to start work on a thesis.

It was still not his intention to stay in geophysics, but this opportunity was too good to miss, and he wrote his thesis on the origin of microseisms, which are small disturbances, more or less continuously registered by sensitive seismographs, constituting the background motion upon which earthquake recordings are superimposed.

Gutenberg got his PhD in 1911, when he was 22 years old, and stayed on at Goettingen to continue his studies in mathematics and physics and his geophysical research. The following year he finished his first major paper—on the core of the earth. This paper, which made the first correct determination of the structure of the earth's central core, is one of Gutenberg's most important contributions to seismology.

Military service

After a year of military service, Gutenberg took a job as an assistant in the central office of the International Seismological Association at Strasbourg, which was then in Germany. He was called back into service, however, when Germany went to war in 1914. On his first day in the field he was hit by an exploding shell, hospitalized, and finally returned to Strasbourg, where he was assigned to the training of volunteers. In 1916 he volunteered himself, for weather-forecasting service, and was sent to the Meteorological Central Station near Berlin.

Strasbourg was occupied by the French at the end of the war. There were few jobs open to German scientists —there or anywhere—and German universities had no money to pay teachers. Gutenberg decided to strike out on his own, and continue with his research and writing.

There was trouble with the family factory though. Beno's younger brother, Arthur, who had been brought up to take over the business, was killed in the war, and Father Gutenberg was too old to handle the factory alone anymore. Beno had to lend a hand.

In 1919 he was married to Hertha Dernburg of Darmstadt. Like most young German women, she had been forced to learn a lot about the world of business during the war, when the men were gone, and she went to work with her husband at the factory now.

During the years of inflation that followed in Germany, the Gutenbergs were better off than most. True, the factory was barely operating at all, and raw materials were almost impossible to get—but soap was so desirable that it was always possible to barter a cake of soap for a pound of butter, or three cakes for a pair of shoes.

In 1923 the University of Frankfurt asked Gutenberg to give courses in geophysics and to take charge of the seismological station at the university's Taunus Observatory. For several years he served the university as a privatdozent (an instructor, actually, but with no other pay than a percentage of the tuition paid by his students). In 1926 he was promoted to Professor Extraordinarius, an impressive title that carried with it an unimpressive stipend—which was at least tax free.

An overloaded life

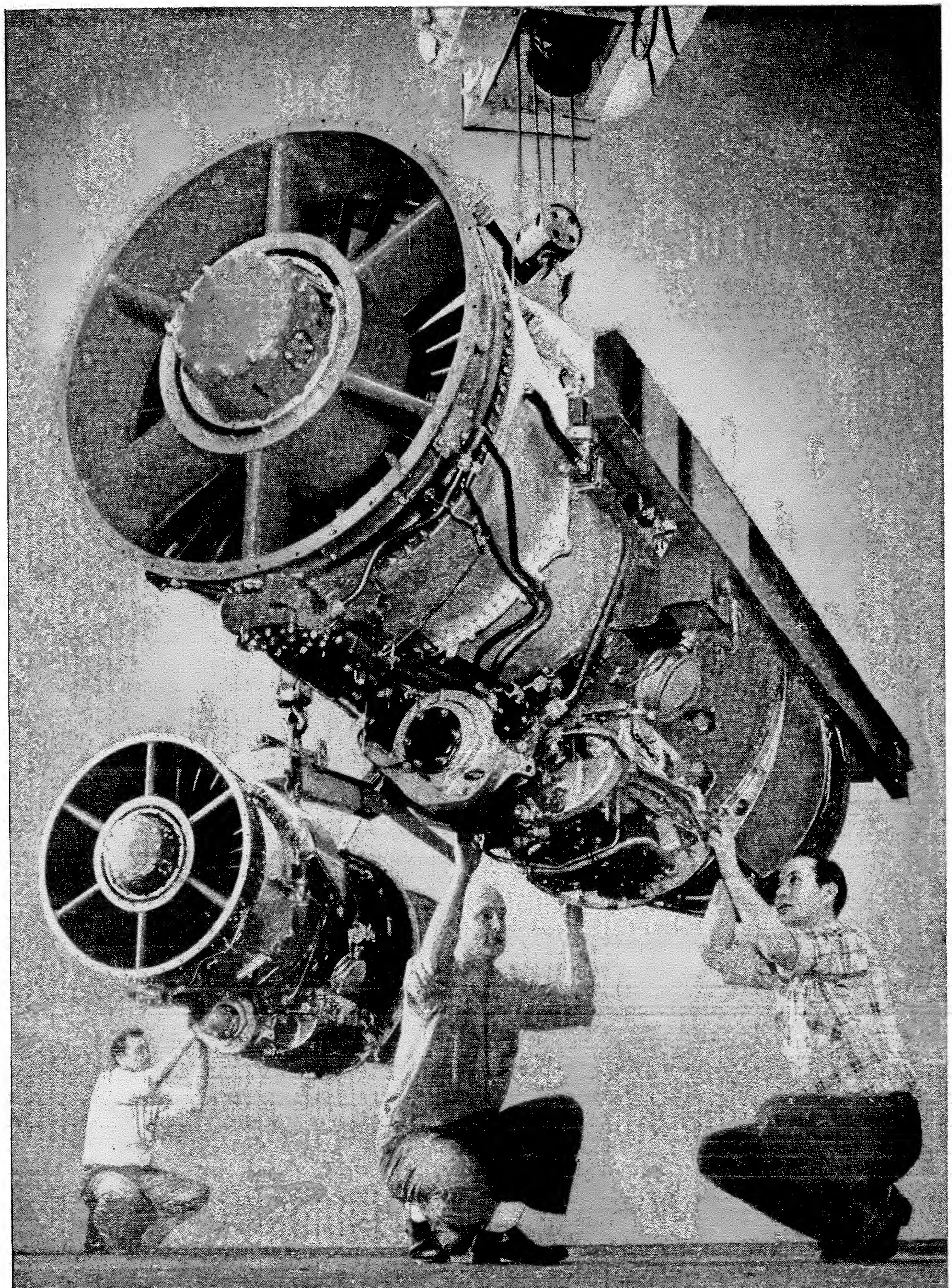
In 1927 Gutenberg's father died. With the help of his wife, he managed to keep the factory going, teach at Frankfurt, and keep on with his research and writing in the evenings. Despite this overloaded life—or very possibly because of it—Gutenberg made some of his greatest contributions during these years. Among other things, he determined the temperature of the upper atmosphere on the basis of the propagation of sound waves; he wrote a textbook on geophysics; he wrote an introductory text on seismology; and he edited the mammoth *Handbook of Geophysics*. He became, in fact, one of the two or three highest internationally recognized authorities in the fields of seismology and geophysics.

In 1929 he was invited by the Carnegie Institution of Washington to attend a conference at the Seismological Laboratory in Pasadena, which was then being administered jointly by Carnegie and Caltech. Once before, Gutenberg had been invited to America, by Harvard, but had turned down the bid to lecture for a year there because he was unable to break away from his business for that long. But the Seismological Laboratory conference was only a two-week affair, and so he accepted—not knowing that he was really going to be looked over as a possible addition to the Laboratory's staff.

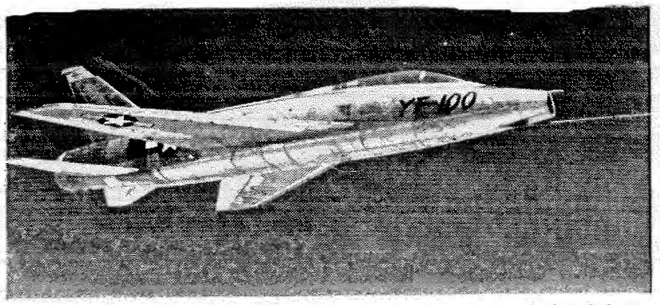
"I'll see you again," R. A. Millikan said significantly, as he was seeing Gutenberg off at the station, after the conference.

"No," said Gutenberg pleasantly, determined never to make this trip this fast again, "I don't think so."

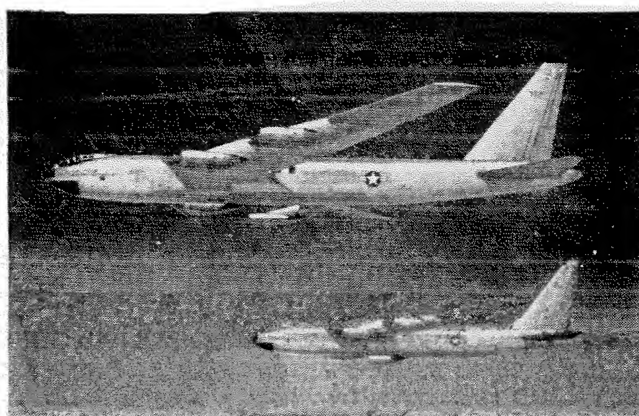
When he was actually invited to join the Laboratory shortly afterwards, it didn't take Gutenberg very long to make up his mind. For one thing, it would mean he could devote all his time to writing and research; for another, it would mean that he and his family would be living in America—and it seemed clear to him then that Europe was heading for another war.

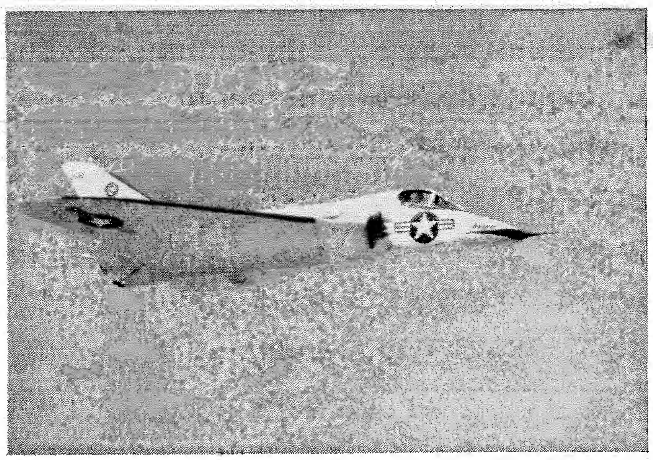


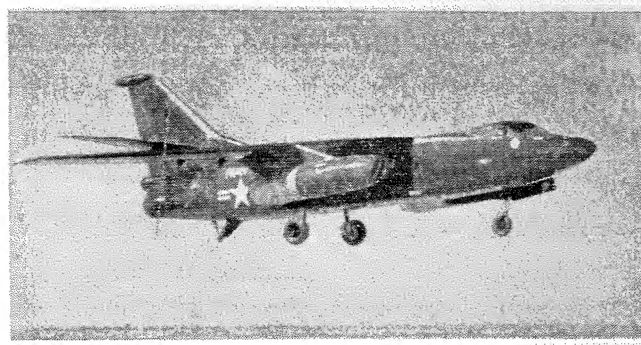
The J-57, in the 10,000-pound thrust class, is the most powerful turbojet engine now in production. A new generation of U.S. air power has been designed around this mighty new Pratt & Whitney Aircraft engine.



North American's F-100 Super Sabre, fastest Air Force jet fighter, is powered by Pratt & Whitney Aircraft's J-57 engine.


First all-jet heavy U. S. Air Force bombers are the huge Boeing B-52s, powered by eight J-57s mounted in pairs.


The Douglas F4D Skyray, fastest Navy jet fighter, will be powered with the big J-57 engine.


The Douglas A3D, the Navy's most powerful carrier-based attack airplane, has two J-57 engines.

Blazing the Way for a New Generation of Air Power

The most powerful turbojet engine in production is blazing the way for a whole new generation of American aircraft.

That engine is Pratt & Whitney Aircraft's J-57, the first turbojet to achieve an official rating in the 10,000-pound thrust class.

But the J-57 provides far more than extreme high thrust. Its unique Pratt & Whitney Aircraft design, achieved after years of intensive research and engineering, offers as well the low specific fuel consumption so vital to jet-powered bombers and future transports, plus the additional important factor of fast acceleration.

The importance of the J-57 in America's air power program is clearly shown by the fact that it is the power plant for three of the new "century series" fighters for the U. S. Air Force—North American's F-100, McDonnell's F-101 and Convair's F-102—as well as Boeing's B-52 heavy bomber. The Navy, too, has chosen the J-57 for its most powerful attack aircraft, the Douglas A3D, the Douglas F4D fighter and for the Chance Vought F8U day fighter. And the J-57 will power the Boeing 707 jet transport.

The J-57 is fully justifying the long years and intensive effort required for its development, providing pace-setting performance for a new generation of American aircraft.

Engineering graduates who can see the challenge in this new generation, might well consider a career with the world's foremost designer and builder of aircraft engines.

PRATT & WHITNEY AIRCRAFT

DIVISION OF UNITED AIRCRAFT CORPORATION

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In 1930 the staff of the Seismological Laboratory (which already included Dr. Hugo Benioff and Dr. Charles Richter) was furnished by the Carnegie Institution, and the buildings and grounds were supplied by Caltech. Gutenberg was actually the first Caltech employee in the Lab, serving also as professor of geophysics at the Institute. After several years he was put "in charge" of the Laboratory, and in 1947, when Dr. L. A. DuBridge became president of Caltech, Gutenberg was given the official title of director of the Lab.

In recent years he has continued to add to the list of his significant contributions to the science of geophysics by working on the development of seismic waves, the structural differences between continents and ocean bottoms, and the earthquake magnitude scale.

In World War II Gutenberg served as a technical adviser for the Navy, helping to set up a typhoon and hurricane warning service. A chain of stations was established to record microseisms, which were then used to locate typhoons in Guam, the Philippines, Florida and throughout the Caribbean area. This kept Gutenberg on the go—to the point where it was not unusual for him to fly 25,000 miles in a matter of two or three weeks.

Not that this shuttle-service traveling was (or is) anything unusual in Gutenberg's life. Constantly being called into consultation, he crosses the continent almost as often as most men cross the street. In a typical year—from the fall of 1954 to the fall of 1955, for example—he will be off to a meeting of the International Geophysical Union in Rome, presenting a paper at the Columbia University Bicentennial Invitational Symposium in New York, and delivering a series of invitational lectures at Cambridge University, the University of London, and the Geological Society of London. Over the years his work has taken him all the way from Japan to Mexico, Canada, New Zealand, Turkey, Israel, the Philippines—and most of Europe.

A past president of the Seismological Society of America, Dr. Gutenberg is a member of the National Academy of Sciences, a Fellow of the Royal Astronomical Society of London, a foreign member of the Academy dei Lincei in Rome, of the Royal Swedish Academy and of the Finnish Academy; and an honorary member of the Royal Society of New Zealand and the Finnish Geographical Society.

The Gutenbergs live in Pasadena. Their son and daughter are now grown and Arthur, who has a PhD in economics, is an assistant professor of economics at Arizona State College; Stephanie is the wife of a physician.

Dr. Gutenberg has been in the United States for 25 years now, but he retains a rich German accent and a way of twisting words around in a sentence that is a constant delight to his colleagues. In fact, he has given his co-workers at the Seismological Laboratory more than one memorable phrase.

In his early days at the Lab, when the records came in on an earthquake, Gutenberg was inclined to burst from his office, streak down the stairs, plunge his hands into the hypo solution in which the records were being developed, hold the records up for a searching look and ask no one in particular, "Here is anything?"

It is, of course, fairly common practice at the Lab, to this day, to point to any unusual peak, valley or dust spot on a record and observe soberly, "*Here* is anything."

The favorite Gutenberg story about learning the language concerns young Stephanie, who was four years old when the family came to America. They had brought their German radio with them and, in Pasadena, Stephanie listened to it for a while with complete fascination.

"Isn't it marvelous," she finally remarked, "how rapidly that little radio has learned English?"

GOOD SAMARITANS, INC.

The Caltech Service League stands ready to handle any emergency in a student's life—whether it involves a necktie, a dentist, a loan or a layette.

by RUTH D. BOWEN

THE Old Woman who lived in a shoe had so many children she didn't know what to do: the Caltech Service League is interested in so many students that there is always something to do.

For the usual situations by which the student is affected there are rules of procedure and definite sources to consult for help, but when the out-of-the-ordinary worry or emergency arises, where does the student away from home, sometimes even in a foreign land, possibly responsible for a wife and young family, turn for a helping hand to tide him over a rough spot?

Such as Jim, whose baby developed frightening symptoms one Thanksgiving Day and needed prompt transportation from a suburban town to Children's Hospital in Los Angeles. In the midst of his worried search for a car Jim was referred to the Service League, which quickly arranged to get them to the hospital.

Or the graduate student here from behind the Iron Curtain who was in very great need of dental work, due to malnutrition and lack of knowledge of dental hygiene. His problem of education, extra needed vitamins and repair work was handled with care and understanding.

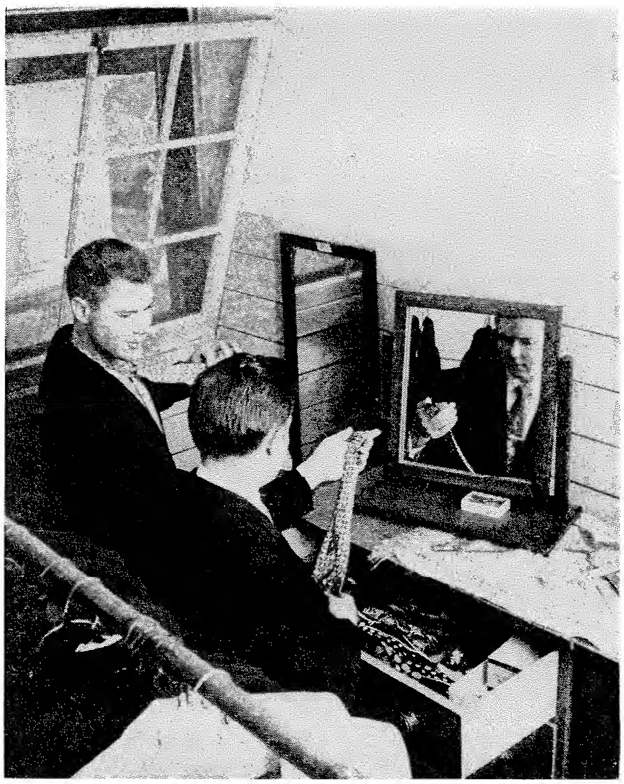
One mother from across the country, whose son was paying court to a local young damsel, remembered the old adage that love is blind and wrote hopefully to the League, wondering if someone knew the young lady. The couple was invited to dinner and mother received a comforting letter about a charming girl. Much later, after she had met her lovely daughter-in-law, the League was thanked again for its friendly reassurance.

Students from other countries sometimes find themselves in tight financial situations due to travel costs, restrictions on amount of money that may be brought out of their native land, sometimes ruinous rates of exchange, our often higher prices, and their inexperience in our customs and habits of living which cause them to misjudge what their income will provide.

For instance, Juan and his attractive bride found, on taking stock around the holidays, not only that their funds had shrunk alarmingly to cover expenses for two for the remainder of the year, but also that another complication had entered the picture—Juan, Jr. must be prepared for. Their concern was eased somewhat by provision of a layette and money to return home on at the end of the year.

Family complications are not the exclusive prerogative of the graduate student. There are a few married undergraduate students, particularly those who have already served their term of military duty. Also, heavy responsibilities and sometimes paralyzing emergencies can occur in the life of an unmarried young student. Not everyone is supplied with the complete quota of family, standing behind him with money or assurance or both.

Arthur, whose mother was a widow, had in his high school days contributed a sizeable amount to the support of his mother and two small brothers. When it became possible for him to attend Caltech on a schol-



Students can borrow ties, shirts, overcoats, tuxedos, sport jackets and slacks from the campus wardrobe.

arship, the mother boarded the smaller boys out in order to hold a job and support them.

For some months everything was under control, until unforeseen circumstances found the mother out of a job and a home. A very worried boy was referred to the Service League. An inexpensive apartment was found for the mother, a job was also provided, the small boys were entered in a Day Nursery, and another valuable young man could return to worrying about math, physics and other simple subjects.

Many of the young families are relieved to find they may borrow needed baby furniture from the Baby Furniture Pool maintained by the League. Large items like cribs, high chairs and play pens are expensive and difficult to transport long distances, or to store for future use in the usual student family.

The bi-monthly Well Baby Conference, with a pediatrician and registered nurse in charge, is always a center of interest. Located in Kerckhoff Biology Laboratory, between a professor's office and a class room, it provides variety to the atmosphere of studious research. (One morning when Dr. Beadle, head of the Biology Division and this year's President of the American Association for the Advancement of Science, poked his head in the door, the Service League chairman handling records for the physician said, in worried accents, "Dr. Beadle, you aren't going to have a class next door every Tuesday morning, are you?" Dr. Beadle's surprised response was, "Why, will we bother you?")

The Service League mothers who maintain the Well Baby Conference never quite become accustomed to the sight of an interested young father from another country whipping out his slide rule to translate infant formulas or baby's weight to the metric system, with which he is more familiar.

Usually the Well Baby Conference gives only a routine physical check, the usual formula adjustments and immunization shots, but on occasion something more serious shows up to the doctor's experienced eyes. One morning it was observed that a baby had a bit of a fever and was unable to straighten one leg. Immediate simple medication was used. X-rays were made at the Health Center and the baby was taken to the Orthopedic Hospital for further observation and treatment. The family was given a loan to take care of the emergency situation.

Interesting as these individual items of assistance may be, actually the major part of the work of the Caltech Service League, organized in 1947 by parents of Caltech students and interested friends, is the general welfare, comfort and morale of the large group of students, supplementing the activities of the regular student organizations where a need is not met through the usual channels.

Our younger generation tends to grow taller, so some special long beds added to the Health Center provide for the comfort of the boys who must spend time in the infirmary. Cookies, fruit juices, soups, magazines and other extras are appreciated. New curtains and upholstery for the remodeled building also make for more cheerful surroundings.

Throop Club, the gathering place for recreation and study for off-campus men, has been the recipient of furniture, draperies, lights, game equipment, records, tools and magazines.

Items of interest

Each year the campus YMCA receives a sizeable contribution, and last year, in addition, draperies, chairs and dishes were provided for their new quarters.

The Franklin Thomas Record Lending Library was established in memory of the former Dean of Students.

A student wardrobe is maintained, from which boys may borrow clothing, such as sport jackets, slacks, tuxedos, dinner jackets, or overcoats to fill a need.

New metal furniture was acquired for the ASCIT Board Room and a pool table, lights and other equipment for the Game Room, used by all the boys in the houses.

Help has been given to the Glee Club, the Ski Hut, and $300 was contributed toward the expenses of eight Caltech delegates to the Inter-Collegiate Model United Nations meeting in San Francisco last spring.

The Student Service Committee is always ready to help individual students when emergencies arise.

Membership in the Service League is a closer tie with the younger generation, helping to make student days more satisfying, and equally, assisting parents and friends to understand more fully the problems with which young people are faced.

Factory testing of "U.S." electrical wires and

In Cable Testing, Part I (No. 9 in the series) this subject was outlined in a general way and Factory Tests on Entire Lengths were discussed in somewhat greater detail. Part II concludes this subject and discusses (in some detail) sample and miscellaneous tests made at the factory and tests after installation.

SAMPLE TESTS

These tests, as the name indicates, are made on short samples selected at any stage during manufacture or from the completed cable.

CONDUCTOR TESTS. Dimensional tests, tensile strength, elongation and quality of coating tests are made on the conductor to insure that the processing operations have been performed properly and that the conductor will meet the specification requirements.

INSULATION AND JACKET THICKNESS. The minimum and average thickness of insulations and jackets are determined by suitable micrometers or micrometer microscopes to determine compliance with the thickness requirements.

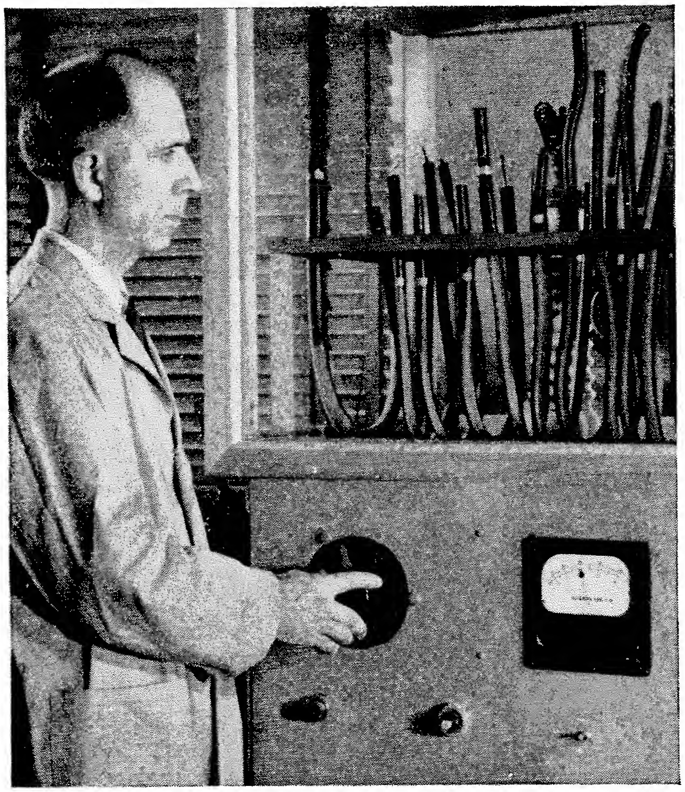
PHYSICAL TESTS. These tests determine the tensile strength, elongation, tensile stress and set of rubber and rubber-like or thermoplastic insulation and jacket compounds. Tensile strength and elongation are measured at the breaking point. Tensile strength in pounds per square inch is calculated from the cross-sectional area of the original test specimen. Elongation is expressed in per cent of the unstretched length. Tensile stress is the tension in pounds per square inch required to elongate a sample a given amount, usually 200 per cent. Set is a measure of the recovery after a specified elongation.

AGING TESTS. These are accelerated tests in which the effect of heat and/or increased oxygen concentration on the tensile strength and elongation of insulations and jackets is determined. The results of such tests indicate the temperature (conductor temperature) at which such insulations or jackets will operate continuously and their life-expectancy at higher temperatures. For example, an insulation that shows not more than 25 per cent depreciation in tensile strength and elongation after 96 hours in the oxygen bomb at 70° C is suitable for continuous operation at 60° C while an insulation that shows not more than 25 per cent depreciation in these characteristics after 168 hours in the oxygen bomb at 80° C is suitable for operation at 75° C.

Electrical tests, such as voltage breakdown, insulation resistance, power factor, etc., are frequently made during the development of insulating compounds to determine the effect of such aging on these properties. Such tests, however, are generally not covered by industry specifications.

MOISTURE ABSORPTION. The effect of moisture on the properties of insulations is important, particularly where they are exposed directly to water in service. Moisture absorption is determined by the gravimetric method and by the electrical method. In the gravimetric method a suitable sample is weighed, immersed in distilled water for 7 days at 70° C and reweighed. The gain in weight is expressed in milligrams per square inch of exposed surface. In the electrical method, the sample is immersed in water at 50° C and its capacitance is determined after one, seven, and fourteen days. The increases in capacitance from the first to the fourteenth and the seventh to the fourteenth days are a measure of moisture absorbed.

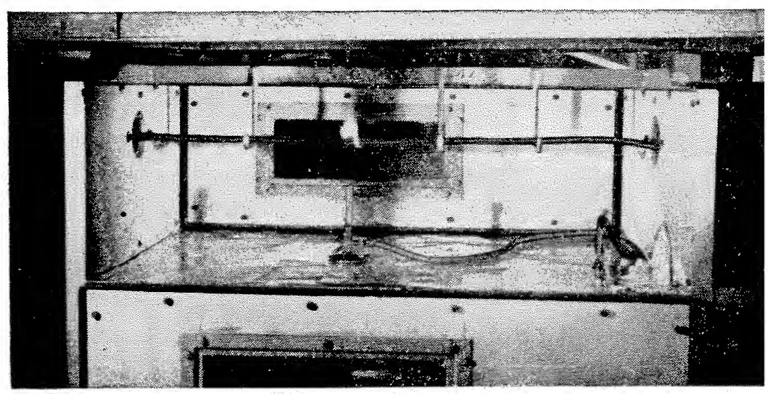
cables–Part 2 *(plus tests after installation)*



DIELECTRIC STRENGTH TEST. Samples of insulated cables designed for operation at voltages above 5001 volts are required to withstand for five minutes the application of a voltage twice the factory test voltage after immersion in water for at least one hour. Following this test, the voltage on the sample is increased 20 per cent and held for five minutes. This cycle is repeated until breakdown occurs and the breakdown voltage recorded for information only.

COLD BENDING AND LONG-TIME DIELECTRIC STRENGTH. Samples of cables designed for operation at voltages above 5001 are required to withstand bending at −10° C around a mandrel approximately ten times the cable diameter followed by the application of the factory test voltage for two hours. This test insures that the insulation and jacket have the required flexibility to withstand bending during installation.

MISCELLANEOUS TESTS. Numerous additional tests are required by specifications for wires and cables to determine their suitability for their particular applications. The more important of these include, abrasion, compression, cutting, low-temperature, tear and weathering tests on insulation and jacket compounds, and abrasion, bending, compression, flame and twist tests on completed cables. The results of such tests are of great value in the design of new types of wires and cables.



OZONE RESISTANCE. To determine the effect of ozone on insulations or jackets, a sample is bent around a mandrel of such diameter that the material under test is stretched about 15 per cent and then exposed to an atmosphere containing ozone at room temperature. One of two concentrations of ozone, namely 0.013 or .027 per cent is used, depending on the type of insulation. Acceptable insulations must withstand such exposure for a specified time without cracking. Ozone resistance is generally required only on those compounds designed for operation at above 5001 volts.

CAPACITY AND POWER FACTOR. The dielectric constant and power factor are important characteristics of insulations designed for use on high-voltage power circuits or on most communication circuits since they are a measure of the energy absorbed by such insulations. The dielectric constant is calculated from capacity measurements on a sample of known dimensions. For high-voltage cables, these measurements are made at the operating voltage of the cable at a frequency of 60 cycles after immersion in water for 24 hours. For communication cables, the measurements are generally made at 1000 cycles with about 20 volts applied to the insulation.

TESTS AFTER INSTALLATION

Wire and cable industry practice permits the application of an a-c voltage equal to 80 per cent of the factory test voltage for five minutes to metallic armored, lead-sheathed or shielded cables immediately after installation. For proof-testing 75 per cent of the factory test voltage may be used. When a d-c test is used, its value for ozone-resistance insulation is three times the a-c value.

To obtain reprints of this advertisement, write Electrical Wire & Cable Department, Rockefeller Center, New York 20, N. Y.

ELECTRICAL WIRE AND CABLE DEPARTMENT

United States Rubber

THE MONTH AT CALTECH

NAS Annual Meeting

The National Academy of Sciences held its annual autumn meeting on the Caltech campus from November 2 to 4. Over 80 members attended the meeting, which featured 50 papers on current research in astronomy, biology, chemistry, engineering, geology, mathematics, and physics.

The National Academy is one of the outstanding scientific organizations in the country, offering membership to only 500 American citizens and 50 foreign associates who have contributed major achievements to science. Members from Caltech include 22 alumni and 27 staff members. Dr. Carl Neimann, professor of organic chemistry at Caltech, acted as general chairman at the autumn meeting.

Leaders of America

Paul G. Hoffman, board chairman of the Studebaker Packard Corporation, spent four busy days on the Caltech campus last month as the first visitor in a new Leaders of America program being sponsored by the Caltech YMCA. Under this program prominent statesmen will visit the campus for informal sessions with the students and faculty. The visits are being financed by the YMCA from funds left in the will of the late Dr. Robert A. Millikan.

Future visitors to the campus in the Leaders of America series will be Justice William O. Douglas, author of books on civil liberties, American law, mountaineering and world travel, who will be at Caltech from January 22 to 27, and Dr. Ralph Bunche, who will be here the week of April 8.

New Trustee

Richard R. Von Hagen, president of the Lloyd Corporation, Ltd., of Los Angeles, was elected last month to the Caltech Board of Trustees. A member of the California Institute Associates since 1947, Mr. Von Hagen is president and director of the Oil Producers Agency of California, a director of the Western Oil and Gas Association, the Independent Petroleum Association of America and the United States National Bank of Portland, Oregon.

Mr. Von Hagen is a graduate of the Law School of the University of Southern California and a member of

Paul G. Hoffman, first visitor in the Leaders of America program, answers questions from students and faculty.

the Los Angeles Bar and the State Bar. He worked for several years with the Los Angeles law firm of O'Melveny and Myers before joining the Lloyd Corporation.

Observatories Meeting

Dr. Vannevar Bush retiring president of the Carnegie Institution of Washington, and Dr. Caryl Haskins, president-elect, visited Caltech and the Mount Wilson and Palomar Observatories last month, to confer with Dr. Ira S. Bowen, director of the Observatories and with other staff members. The Observatories are operated jointly by the Carnegie Institution and Caltech.

Dr. Bush has been president of the Carnegie Institution since 1939. He originated the plan for the wartime office of Scientific Research and Development and served as its director from 1941 to 1946. He is now a member of the advisory committee of the National Security Resources Board.

Dr. Haskins assumes the presidency of the Carnegie Institution on January 1, 1956. He established his own laboratories in New York to carry on biochemical, biophysical and other research, after receiving his PhD from Harvard in 1935. While maintaining his research interests, he has held faculty appointments at the Massachusetts Institute of Technology, and Union College, Schenectady, and has served in a leading capacity as a research official and adviser to the government.

Honors and Awards

President L. A. DuBridge has been named chairman of the Board of Trustees of the independent Air Pollution Foundation, succeeding Raymond B. Allen, chancellor of the University of California at Los Angeles. Dr. DuBridge was one of the founders of the Air Pollution Foundation, a scientific organization devoted to the elimination of smog.

Dr. Theodore Von Karman, director of the Guggenheim Aeronautical Laboratories, has been named chief of the planning board and a director of Gruen Precision Laboratories, Inc. This newly formed subsidiary of the Gruen Watch Company of Cincinnati will engage in the engineering and development of precision products for national defense and industrial application.

Robert T. Knapp, professor of hydraulic engineering, received the Melville Medal of the American Society of Mechanical Engineers, for the best original paper of the year ("Recent Investigations of the Mechanics of Cavitation and Cavitation Damage") at the society's annual meeting in Chicago last month. Chairman of the cavitation committee of the hydraulic division of the ASME, Dr. Knapp has been a national lecturer for the society for two years.

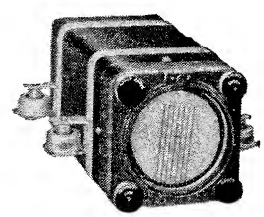
New RCA Radar "Weather Eye" Sees Through Storms

In our time, Man has won round after round in a contest against the elements that started thousands of years ago.

The most recent scientific victory is something new in Radar—an electronic "Weather Eye" developed by RCA.

In airplanes, this supersensitive instrument peers miles ahead. It gives advance warning of weather disturbances. The signals on its radar screen point the way to a safe course *around* storm areas, or even *through* them.

The leadership in electronic research that made the "Weather Eye" possible is inherent in all RCA products and services. And at the David Sarnoff Research Center of RCA, Princeton, N. J., scientists are continually at work to extend the frontiers of "Electronics for Living."



New RCA Weather Mapping Radar weighs under 125 pounds, takes little space in a plane.

For information regarding design and development engineering positions on such projects as "Weather Eye" Radar and military electronic equipment—write to Mr. Robert Haklisch, Manager College Relations, Radio Corporation of America, Camden 2, N. J.

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ALUMNI NEWS

Winter Dinner Meeting

THE WINTER ALUMNI Dinner Meeting, to be held on January 12, will have Dr. Gilbert Brighouse, professor of psychology at Occidental College, as He will talk on "The Personal Side of Success."

Dr. Brighouse is no stranger to Caltech; he lectured in psychology here from 1940 to 1947. He has also served as consulting psychologist to numerous industrial and business firms in this area for many years.

The January 12 dinner will be held at the Rodger Young Aditorium, 936 West Washington Boulevard, Los Angeles, at 7 p.m. Dinners will cost $3.50 (including tax and tip). Alumni, wives and guests are all invited.

Alumni Homecoming

WHAT WITH THE Pasadena Fire Department frowning on the notion of a Caltech bonfire, and the memory of last year's rather dismal barbecue prior to the Occidental game still fresh in their minds, the ASCIT Board of Directors were in somewhat of a quandary, wondering how the Alumni Homecoming was to be commemorated, other than by the game itself. After half a dozen ideas had been examined and voted down, someone suggested that, since this was a Homecoming game—why not a Homecoming Queen?

Everyone seemed pretty well satisfied with the idea of a queen and, after the various ramifications of selecting one were explored, it was decided to put the ASCIT Rally Commissioner in charge of the entire affair.

The day of the game, November 12, dawned cloudily, with a hint of rain in the air. But, although it looked ominous, the weather held, and promptly at six p.m., a picnic supper was served to men from the student houses, dates, off-campus students, and a few interested faculty members, at Brookside Park, adjacent to the Rose Bowl. A few minutes before eight the mass exodus to the Bowl started.

The Caltech team looked fairly good during the first half, and spirit was pretty high as the Queen, Miss Sandra Nash, and her two princesses, Georgine Johnson and Mickie Hale, were driven around the track in the traditional top-down convertible, then crowned by alumni prexy C. Vernon Newton.

Despite the fact that Caltech had come out on the short end of a 35-7 score, people were still happy enough to enjoy a couple of hours of dancing (in stocking feet, of course) in the Scott Brown Gymnasium, the first such event held there.

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Meetings: Informal luncheons every Thursday.
Fraternity Club, 345 Bush St., San Francisco.

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ALUMNI DIRECTORY

A supplement to the 1954 Alumni Directory will be issued late this fall listing the names and addresses of those who received degrees in 1954 and 1955. Copies of this supplement will automatically be sent to paid alumni who graduated in these years. Other alumni may secure copies by sending the form below to the Alumni Office.

Please send the Alumni Directory supplement to:

Name..

Address..

City......................................**State**..........................

Alumni News . . . CONTINUED

Now that the first annual (we hope) Alumni Homecoming was over with, the results were examined critically. The first bone of contention among students was that they had had no part in picking the royal court. Hemming and hawing, the Rally Commissioner reluctantly admitted that he was responsible for selecting the three girls, asked for concrete suggestions for next year—and received zero.

Secondly, alumni were somewhat disgruntled because there had been nothing planned expressly for or by them, although it was supposed to be their Homecoming which was being celebrated.

However, despite these and other complaints, the overall opinion was that a second annual Alumni Homecoming would certainly be in order, and meetings between ASCIT and alumni officers in the spring might prove to be valuable in planning for it.

—*Frank Kofsky, ASCIT Rally Commissioner*

Alumni-Varsity Water Polo

FROM BILL BARMORE '52 comes a belated report on the first annual Alumni-Varsity water polo game, played on the evening of October 12 in the Alumni Pool.

"The whole scheme started out as a good excuse to get to swim in the Alumni Pool for free. Before we realized it, we were scheduled to actually play the game. After deciding that seven good alumni could whip any seven young upstarts the varsity could produce, we threw ourselves into a rigorous (well, two or three nights a week, anyway) training schedule. On the night of the game we were confident of our team's ability—but then they made us take off our swim fins.

"With a tremendous burst of energy, we went into the lead in the first seconds of play with a 50-foot shot by Dixon. When the opening whistle blew, Merrick raced for the ball, threw it to Dixon, and then came our moment of glory. Unfortunately, from there on, things went downhill.

"The members of the team were:

Bill Dixon '48 (his arm saved the day)
Brad Houser '51 (the brains behind the idea)
Bill Barmore '52 (that's longer ago than it sounds)
Bob Merrick '02 (that's what he said, but 1942 sounds better)
Ron Cochrane '55 (a mere youngster)
Al Haire '53 (he was in condition)
Jim Wyman '53 (all the way from San Pedro)
Ed Reinecke '50 (anybody want a good sprinkler system?)
Jay Montgomery '50 (the game was all new to him)
Peter Augusztiny (an import from Canada)
Harry Lawrence (ex-Oxy, now a grad student)

"The final score? Varsity 12 — Alumni 3."

PERSONALS

1917

Paul D. V. Manning was recently made an honorary member of the American Institute of Chemists. After receiving his MS at Caltech, Paul got his PhD at Columbia University, then spent the years from 1925 to 1941 in various industrial positions on the West Coast, and lectured in chemical engineering at Stanford on the side. In 1941 he became director of research of the International Minerals and Chemical Corporation in Chicago, and he has been vice-president of the firm since 1943.

1924

Edgar N. Layton and his family moved to Concord, California, last year, when Ed was transferred by the Fluor Corp. to serve as assistant manager of Fluor Maintenance, Inc. He writes: "We like the Bay Area and were glad to get out of Smogtown. Have had the same wife, Anne, for 30 years, a son, 12, in school locally, and a daughter who has been married two years, living in San Jose. We recently learned that we will soon be grandparents. Have enjoyed meeting many old-time alumni at the weekly luncheons in San Francisco, and at *Bob Bowman's* ('26) annual alumni barbeque in Concord in September."

1929

Reymond J. Kircher, formerly with the Bell Telephone Laboratories, has joined the technical staff of the Systems Laboratories of Hughes Research and Development in Culver City, California.

1931

John R. McMillan is now executive vice-president of the Monterey Oil Company in Los Angeles. He was formerly vice-president of the Fullerton Oil Company of Tulsa, which has now become a part of the Los Angeles organization.

1932

Edward C. Keachie, associate professor of industrial engineering at the University of California in Berkeley, is now in Darmstadt, Germany, for a year as a Fulbright instructor at the Technische Hochschule. His wife and three children (Stephen, 14, Douglas, 10, and Pamela, 4) are with him. Ed says he expects to gather more material while in Germany for his study of industrial firms' methods of analysis of plant and equipment spending.

1932

Clark Goodman is taking a leave of absence from MIT to become assistant director of the Reactor Development Division of the Atomic Energy Commission. Now on a part-time basis, he will probably move to Washington about the beginning of February. "During the past year," Clark says, "my wife and I each had Fulbright Fellowships in Japan. We had a wonderful experience and feel that we learned to understand and appreciate the Japanese people. Our children attended an all-Japanese school and certainly did their share in furthering international good will."

William Shockley, who joined the Bell Telephone Laboratories in 1936, and has been director of transistor physics there since 1954, is now with Beckman Instruments, Inc., in Fullerton, California. He is building a new research group to further development of the semiconductors from which transistors are made.

1933

Robert S. Rose, Jr., PhD, has been named assistant director of the chemical research department of the Atlas Powder Company in Wilmington, Delaware. Bob has been with Atlas since 1935.

1933

Carlton R. Worth, PhD, has been appointed assistant professor of mathematics at Ithaca College, New York.

Ralph Hultgren, PhD, professor of metallurgy at the University of California, will be at Caltech from February until June next year on a sabbatical leave. While here he will study metallic chemical bonding with Dr. Pauling. Ralph's son, Neilen, has enrolled at Caltech this fall as a graduate student in chemistry.

1934

G. Sidney Smith, director of research for Carlon Products, Inc., in Cleveland, writes that, "We are moving into a newly built home in Kent with our sons, 16 and 14, and daughters, 11 and 8. Busy with Soap-Box-Derby clinics, Boy Scouts, A.S.T.M., business trips, and sons' hobbies of radios and chemistry. Spent an evening recently with roommate *Johnny Little* ('34) of Sandusky, Ohio, after 21 years!"

1935

Hsia-Chien Huang, MS, PhD '38, an escapee from Red China, is now with the American Institute of Aerological Research in Denver, Colorado. His one regret is that his eldest son is still in China, although his wife (a former high school teacher in China) and his other two sons are here with him. He was head of the department of meteorology in the National Central University before the political changes in China, and established the first nationwide weather reporting system, the Central Weather Bureau of China.

Oliver C. Dunbar reports that, after nine and a half years in the U.S., he's "being shipped back overseas, Army Signal Corps, to head the Engineering Branch, Communication Division, at Camp Zama near Tokyo, Japan. This will mean a three-year tour of duty so my family and I probably won't be back until 1959."

Wallace Johnson, president of Up-Right Scaffolds, writes from Berkeley, Calif., that he combined a recent pleasure trip to Europe with business and arranged licensing agreements with a company in

Personals . . . CONTINUED

England and one in Switzerland to manufacture and sell his aluminum scaffolds.

1936

Frank J. Malina, MS '35, PhD '40, had a one man show in Paris recently of his electro-paintings. He writes: "You might say I am trying in a small way to bridge the gap between science and art. Last year the city of Paris purchased one of my wire screen transparents, which was both encouraging and satisfying to one who has strayed a long way from rocket research."

F. L. Johnson, manager of physical research and development of the Sun Oil Company in Dallas, has been appointed director of production research and development for the same organization.

1937

John R. Schultz, PhD, has been made chief geologist of the Manu-mine Research and Development Company in Reading, Pa. He had been with the U. S. Engineers in Vicksburg, Miss., for a number of years before this change.

1938

Maurice J. Schlatter, PhD '41, writes that he is "employed at the California Research Corporation in Richmond, and now have a son, four months old. Janie, 12, and Susan, 9, are wholeheartedly exercising their maternal instincts in helping their mother and father bring up Ronald Maurice 'properly.'"

Carlton L. Horine, who has been working at the Naval Ordnance Test Station at Inyokern, has now joined the development department of Brea Chemicals, in Brea, California, as senior process engineer.

1939

Edmund J. Pinney, PhD '42, is associate professor of mathematics at the University of California at Berkeley.

1940

Mark Muir Mills, PhD '48, is now working at the Livermore site of the University of California Radiation Lab as head of the theoretical division, and is also teaching nuclear engineering at Cal. He and his wife, Polly, have two children, Mark John, 9, and Ann, 6.

Miller W. Quarles, Jr., MS '41, resigned his position as chief geophysicist and Gulf Coast manager of the Precision Exploration Company in June. He is now with Ralph E. Fair, Inc., in San Antonio, Texas, as geologist and geophysicist.

Robert S. Neiswander, MS '46, PhD '54, is now a member of the technical staff of the electronics tube laboratory of Hughes Research and Development. He was formerly with Aerojet as an engineer.

1942

Robert A. Spurr, PhD, formerly associate professor of chemistry at the University of Maryland, is now a member of the research laboratories at Hughes Aircraft in Culver City, California.

Philip O. Johnson, MS '43, has joined the Semi-Conductor Laboratory at Hughes Aircraft. He had been working at North American Aviation.

1943

Amasa Stone Bishop is heading the Atomic Energy Commission's Sherwood Project in Washington, D.C., which is doing research on the conversion of sea water into usable energy.

Raymond Homer Simpson, MS, died of cancer on March 25 at his home, 105 Highland Avenue Drive, Lamesa, Texas. He was a wholesale agent for the Humble Oil and Refining Company. Ray is survived by his wife, Evelyn Storey Simpson, two sons and one daughter.

Herbert A. Lassen, PhD '50, who is with Hughes Aircraft as a senior staff engineer, is teaching a course in advanced kinematics of mechanisms at the UCLA Engineering Extension Division in Los Angeles.

Richard M. Lemmon, MS, is a chemist in the radiation laboratory at the University of California in Berkeley. He is also serving as secretary of the California Section of the American Chemical Society.

Alexander C. Ridland is now with Solar Aircraft as an experimental engineer in their gas turbine project in San Diego. Before going to Solar, he had worked with Convair in design engineering. Alex, his wife, and two children live in Rancho Santa Fe, near San Diego.

1946

George R. Watt has been named product planning coordinator for the Consolidated Engineering Corporation in Pasadena. George has been with Consolidated for two years as a market research engineer.

Donald Gray Furst, MS '48, has been transferred to Phoenix as an assistant project engineer in charge of development of two gas turbine engines for the AiResearch Manufacturing Company.

John O. Nigra, MS, is back at Tulane University after spending a year in Iraq on a Fulbright Fellowship.

Ali Bulent Cambel, MS, has received a Fellow Membership in the American Rocket Society. He is an associate professor of mechanical engineering at Northwestern, in charge of the university's gas dynamics laboratory.

1947

David L. Douglas, PhD '51, recently transferred from the chemistry section of the Knolls Atomic Power Laboratory, operated by General Electric for the AEC, to the G.E. Research Lab (chemistry research department), in Schenectady.

Telford Oswald, MS, PhD '51, senior staff engineer in the guided missiles division of Hughes Aircraft, is lecturing in intermediate fluid mechanics this fall at UCLA.

1948

Lt. Col. Edward N. Hall, MS, has received the Robert H. Goddard Memorial Award from the American Rocket Society for his development of liquid propellant rockets. Ed is supervisor of propulsion at the Western Development Division headquarters of the Air Research and Development Command in Inglewood, California.

Abner Kaplan, MS '49, is now working in the aeromechanics group of the Guided Missile Research Division of the Ramo-Wooldridge Corporation in Los Angeles. The Kaplans have two children, Eric David, 4, and Ellen Louise, 1.

Donald P. Wilkinson, who was formerly with the technical staff of the Propulsion Research Corporation, has joined the sys-

tems division of Hughes Research and Development in Culver City, California.

1949

Edward C. DuFort, MS '52, writes that he is "still with Continental Oil Company and was transferred to Houston last month. Now have an energetic son running about. All is well except my golf game."

Albert S. Hook, recently became a member of the advanced electronics laboratory of Hughes Research and Development. He was formerly with the National Cash Register Company.

1950

Carel Otte, MS, PhD '54, and his wife, Mary have a four-month-old son, Stuart Carel. They're living in Casper, Wyoming.

Jerome E. Jacobs, MS '51, a member of the technical staff of Hughes Aircraft, is a lecturer in engineering this fall at UCLA. He's teaching a course in basic electronics.

Ralph Lutwack, PhD '55, recently joined the Shell Development Company's Emeryville, California, Research Center as a chemist in the lubricants general department.

James C. Blom, who received his PhD at Innsbruck in 1953, recently completed a hitch in the Corps of Engineers, and is now working for the Standard Oil Company. He is the father of a baby girl, Monica Charlotte.

1951

Robert H. Harner, MS, who is working as a development engineer with the S. and C. Electric Company in Chicago, was married last March to Mary E. Forsland of Chicago.

Robert Hildebrand Ahlers, MS, is now working at the Dow Chemical Company in Midland, Michigan.

Jan A. Narud, MS, received his PhD at Stanford last spring and was appointed assistant professor at Harvard University this summer. Jan and his wife have a six-month old son.

1952

William L. Wise writes that he is in the development laboratory of the Hewlett-Packard Company in Palo Alto and reports that altogether, six engineers of Tech origin are with the Lab. Bill and his wife have three children, Lawrence, 3, Sandra, 19 months, and Teri, 4 months.

John Baugher is back at Caltech studying for an MS in electrical engineering.

Dick Quan, MS, is employed as a design group leader in the design analysis section of the Gas Turbine Division of A. V. Roe, Canada, in Toronto.

1953

David J. MacDonald, Jr., MS '54, is stationed at Dugway proving ground in the Chemical Corps of the Army.

Arnold A. Strassenburg, MS, is assistant professor of physics at the University of Kansas.

Earl D. Jacobs, MS, has joined the technical staff of the electron tube laboratory at Hughes Research and Development in Culver City.

William D. Gardner resigned his commission in the U.S. Coast and Geodetic Survey and is assistant director of Public Works for Corona, California. He was recently married to the former Barbara Paton.

Edwin Jule Stofel was married in Glendale to Connie Orr, a student at UCLA. Edwin is stationed in San Francisco with the Army.

Neal H. Cosand is working for his MS under a Hughes Cooperative Program fellowship, and working concurrently in the Field Engineering Division. *Daniel Gerlough*, BS '37, is also on the technical staff of Hughes, at Culver City.

1954

Frederick W. Garrison is working for General Electric in Schenectady. He and his wife, the former Ramona Fulp, have a daughter, Vicki Lynn, three months old.

Robert Keith Campbell is also in Schenectady, working in General Electric's turbine department.

1955

Allen I. Ormsbee, PhD, *Walter A. Johnson*, MS, *Regis E. Neuman*, MS, and *Martin Vogel* have all joined the technical staff at Hughes Research and Development at Culver City.

Edwin J. Furshpan, PhD, is working with Professor B. Katz at the University College in London. He will be there for a year on a National Science Foundation postdoctoral fellowship.

Roy Sachs, PhD, is in Italy at the University of Parma. His research is in plant physiology and is sponsored on a fellowship from the National Science Foundation.

David R. Viglierchio, PhD, is at the University of California in Davis, Calif. His work is concerned with plant nematology.

Charles J. Brokaw is doing graduate work at the University of Cambridge in England.

Ernest A. Dernburg has been awarded a graduate assistantship at UCLA and is majoring in zoology.

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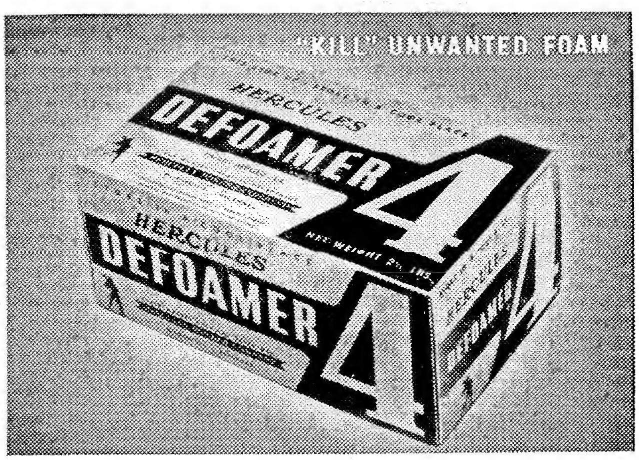

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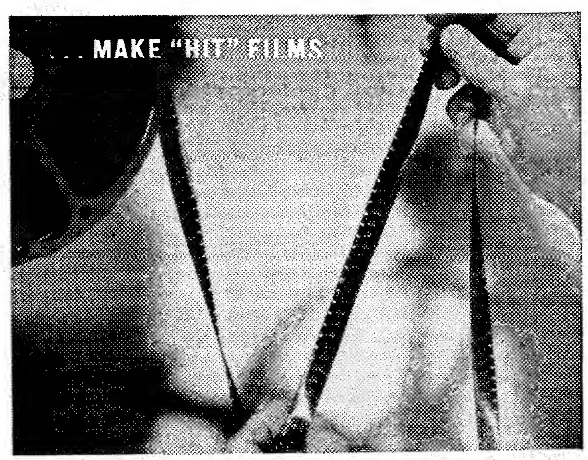

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G55-10

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LOST ALUMNI

The Institute has no record of the present addresses of the men whose names appear in the list below. If you find your own name here—or that of someone you know—please drop a card, giving the current address, to the Alumni Office, C.I.T., 1201 E. Calif. St., Pasadena 4.

1906
Norton, Frank E.

1911
Lewis, Stanley M.

1921
Wulff, Robert G.

1922
Beman, Willard J.
Cox, Edwin P. MS

1923
Skinner, Richmond H.

1924
McKaig, Archibald
Tracy, Willard H.

1925
Aggelear, William F.
Bailey, Emerson
Smith, Dwight O.

1926
Barnes, Orrin H.
Chang, Hung-Yuan
Huang, Jen Chieh
Huang, Y. H.
McCarter, Kenneth C.
Schueler, Alfred E.
Yan, Kai Jin

1927
Langer, R. Meyer, Ph.D.

1928
Chou, P'ei-Yuan, Ph.D.
Hicks, Hervey C., Ph.D.
Martin, Francis C., MS
Morgan, Stanley C., MS

1929
Nagashi, Masahiro H.
Nelson, Julius (Espinosa)
Reed, Albert C.
Robinson, True W.
Sandberg, Edward C., MS

1930
Chao, Chung-Yao, Ph.D.
Douglass, Paul W., Sr.
Janssen, Philip
Russell, Lloyd W.
West, Steward. MS
White, Dudley
Wilkinson, Walter D. Jr.

1931
Crossman, Edward B.
Ho, Tseng-Lo, MS
Matison, Harry
Newby, Oscar M.
Voak, Alfred S.
West, William T.
Woo, Sho-Chow, Ph.D.
Yoshoka, Carl K.

1932
Fraps, A. W., MS
Harshman, E. Nelson
Marshall, Donald E. MS
Oulton, Thomas D.
Schroder, L. D. MS
Wright, Lowell J. MS

1933
Applegate, Lindsay M. MS
Ayers, John K.
Downie, Arthur J.
Hill, James W.
Hsu, Chuen Chang MS
Larsen, William A. MS
Lockhart, E. Ray
Michal, Edwin B.
Murdock, Keith A. MS
Pauly, William C.
Rice, Winston H.
Shappell, Maple D. Ph.D.
Smith, Warren H.

1934
Harshberger, John D.
Liu, Yun Pu Ph.D.
Lutes, David W.
Radford, James C.
Read, John Ph.D.

1935
Becker, Leon
Ehrenberg, Gustave Jr.
Gelzer, John R.
Huang, Fun-Chang MS
Jackson, Oscar B. MS
Kells, Edward L. MS
Kitusda, Kaname MS
McNeal, Don MS
Obatake, Tanemi

1936
Bassett, Harold H. MS
Chu, Djen-Yuen MS
Creal, Albert
Fahrner, Ted
Kelch, Maxwell
Kurihara, Hisayuki
Nutting, Perley G.
Ohashi, George Y.
Onaka, Takeji MS
Rector, Eugene M.
Weber, Bruce T.

1937
Burnight, Thomas R.
Cheng, Ju-Yung MS
Davis, Roderic C. MS
Easton, Anthony MS
Fan, Hsu Tsi MS
Jones, Paul F. MS
Lotzkar, Harry MS
Maginnis, Jack MS
Moore, Charles K. MS
Munier, Alfred F. MS
Nojima, Noble
Park, Noel R. MS
Parry, H. Dean
Penn, William L. Jr.
Rechif, Frank A.
Servet, Abdurahim MS
Shaw, Thomas N.
Tsubota, George Y. MS
Yin, Hung Chang Ph.D.

1938
Ackerman, John B. MS
Gershzohn, Morris MS
Goodman, Hyman D. MS
Kanemitsu, Sunao MS
Lowe, Frank C.
Ofsthun, Sidney A. MS
Okun, Daniel A. MS
Stone, William S. MS
Tilker, Paul O.
Tsao, Chi-Cheng MS
Velasquez, Jose L.
Wang, Tsun-Kuei
Watson, James W.

1939
Asakawa, George
Brown, William
Burns, Martin C. MS
Jackson, Andrew M. MS
Jones, Winthrop G. MS
Kyte, Robert M.
Liang, Carr Chia-Chang MS
Neal, Wilson H. MS
Robertson, Francis A.
Sinclair, George W.
Tatom, John F. MS

1940
Batu, Buhtar
Epstein, Ludwig I.
Green, William J. MS
Heywood, Harold E. MS
Hines, Marion E.
Hsu, Chang-Pen
Paul, Ralph G.
Tajima, Yuji A.
Tao, Shih Chen MS
Ustel, Sabih A. MS
Wang, Tsung-Su MS

1941
Blake, Charles L. MS
Bruce, Sydney C. MS
Clark, Morris R.
Damberg, Carl F. AE
Dieter, Darrell W. MS
Easley, Samuel J. MS
Feeley, John M.
Green, Jerome
Jones, Glyn Frank
Jones, John W.
Kuo, I. Cheng Ph.D.
Robinson, Frederick G.
Skalecky, Frank H., Jr.
Standridge, Clyde T. MS
Stephenson, William B. MS
Taylor, D. Francis
Tyler, Edmund F.
Vartikian, Onick
Waigand, LeRoy G. MS
Whitfield, Hervey H. MS
Yui, En Ying MS

1942
Bebe, Mehmet F. CE
Bergh, Paul S.
Callaway, William F.
Chastain, Alexander
Holser, William T.
Hughes, Vernon W. MS
Levin, Daniel MS
MacKenzie, Robert E.
Martinez, Victor H. MS
Sternberg, Joseph

1943
Angel, Edgar P. MS
Anspach, Kenneth E.
Bethel, Horace L. MS
Bryant, Eschol A. MS
Burlington, William J. MS
Carlson, Arthur V. MS
Colvin, James H. MS
Daniels, Glenn E. MS
Enikeieff, Oleg C.
Hamilton, William M. MS
Hewson, Lawrence MS
Hillyard, Roy L. MS
Hilsenrod, Arthur MS
King, Edward G. MS
Koch, Robert H. MS
Kong, Robert W. MS
Lee, Edwin S., Jr. MS
Leeds, William L. MS
Ling, Shih-Sang MS
Lobban, William A. MS
Lundquist, Roland E. MS
Mampell, Klaus Ph.D.
McNeil, Raymond F. MS
Mixsell, Joseph W. MS
Moore, Paul R. MS
Mowery, Irl H. Jr. MS
Nesley, William L. MS
Neuschwander, Leo Z. MS
Newton, Everett C. MS
O'Brien, Robert E. MS
Patterson, Charles M. MS
Pearson, John E. MS
Rambo, Lewis
Rivers, Nairn E. MS
Roberts, Fred B. MS
Rupert, James W. Jr. MS
Scholz, Dan R. MS
Shannon, Leslie A. MS
Tindle, Albert W. Jr. MS
Vicente, Ernesto MS
Walsh, Joseph R. MS
Washburn, Courtland L. MS
Weis, William T. MS
Wood, Stanley G. MS
Yung, Chiang H. MS

1944
Ahuza, Victor B. MS
Alpan, Rasit H.
Barriga, Francisco D. MS
Bell, William E. MS
Berkant, Mehmet N. MS
Birlik, Ertugrul MS
Burch, Joseph E. MS
Burke, William G. MS
Cabral, H. J.
De Medeiros, Carlos MS

Estrada, Neil S. MS
Fu, Ch'eng Yi PhD
Harrison, Charles P. MS
Hu, Ning PhD
Johnson, William M. MS
Kern, Jack C. Jr. MS
Labanauskas, Paul J. MS
Leenerts, Lester O. MS
Mattinson, Carl O.
Parker, Theodore B. MS
Rempel, John R. MS
Shults, Mayo G. MS
Stanford, Harry W. MS
Stein, Roberto L. MS
Sullivan, Richard B. MS
Sunalp, Halit MS
Taylor, Garland S.
Trimble, William M.
Unayral, Nustafa. A.
Wilson, John H.
Wood, George M.
Writt, John J. MS
Yik, George

1945

Bunze, Harry F. MS
Clementson, Gerhardt C. MS
Gibson, Charles E. MS
Jenkins, Robert P.
Jordan, Robert B.
Knox, Robert V.
Pooler, Louis G. MS
Romney, Carl F.
Tatlock, William S.
Taylor, Robert W.
Tiernan, William F. Jr. MS
Werme, John V.
Zabriskie, Jesse H. MS

1946

Barber, John H. MS
Burger, Glenn W. MS
Conradt, Robert H.
Dethier, Bernard
Dyson, Jerome P.
Esner, David R.
Hoffman, Charles C. MC
KeYuan, Chen MS
Lang, Serge
Lewis, Frederick W. MS
Lowery, Robert H. MS
MacDonald, Norman J.
Maxwell, Frederick W. MS
Miller, Jack N. MS
O'Meara, Donald J. MS
Simmons, George F.
Sledge, Edward C. MS
Smith, Harvey F. MS
Srinivasan, Nateson MS
Tung, Yu-Sin MS
Uberoi, Mahinder S. MS
Weitzenfeld, Daniel K. MS
Williams, Ralph C. MS

1947

Atencio, Adolfo J. MS
Dagnall, Brian D. MS
Hsueh, Chi-Hsun MS
Hsu, Chi-Nan MS
Huang, Ea-Qua MS
Hutchison, Paul T. MS
Kamath, Mundkur V. ID
Leo, Fiorello R. MS
McClellan, Thomas R. MS
Molloy, Michael K. MS
Monoukian, John MS
Moorehead, Basil E. A.
Nelson, Conrad N. MS
Pascoe, Lucien A.
Rosell, Fred E. Jr. MS
Sappington, Merrill H. MS
Shackford, Robert W. MS
Swatta, Frank A. MS
Vanden Heuvel, George MS
Veale, Joseph E. MS
Wan, Pao Kang MS
Wellman, Alonzo H. MS
Ying, Lai-Chao MS

1948

Agnew, Haddon W. MS
Bingham, Andrew T. MS
Blue, Douglas K. MS
Browne, Charles I. Jr. MS
Bunce, James A. MS
Collins, Burgess F.
Crawford, William D. MS
Eldin, Hamed K. MS
Hsiao, Chien MS
Hsieh, Chia Lin MS
Mason, Herman A.
McCollam, Albert E. MS
Morehouse, Gilbert G. MS
Oliver, Edward D. MS
Rhynard, Wayne E. MS
Stewart, Robert S. MS
Swain, John S.
Swan, Walter C. ME
Swank, Robert K. MS
Walters, James W. Jr. MS
White, Harvey J. ID
Winniford, Robert S. MS
Yanak, Joseph D. ChE

1949

Baumann, Laurence I.
Blazina, Thomas D. MS
Bottenberg, William R. AE
Clancy, Albert H. Jr. AE
Clendening, Herbert C. MS
Craighead, Emery M. MS
Davis, Raymond E.
Darrow, Robert A.
Foster, Francis C. ID
Hrebec, George W.
Krasin, Fred E.
Lowrey, Richard O. MS
MacKinnon, Neil A. AE
Matteson, Robert C. MS
McElligott, Richard H. AE
Petty, Charles C. MS
Smith, Vernon L.
Weiss, Mitchell MS
Yu, Sien-Chiue PhD

1950

Curtis, Robert N.
Hitchcock, Thomas P.
Hottenroth, James H. MS
Hughes, John D.
Li, Chung Hsien MS
McDaniel, Edward F. MS
McLaughlin, Jack E. PhD
McMillan, Robert MS
Monroe, Alfred J. MS
Nelson, Robert C. MS
Pao, Wen Kwe PhD
Roberts, Morton S. MS
Roddick, James A. MA
Schneider, William P. MS
Shen, San-Chiun PhD
Spevak, Ezra MS
Sullivan, John H. PhD
Vivian, James A. MS

1951

Arosemena, Ricardo MS
Carter, Cecil V. MS
Dankworth, E. G. Jr. AE
Davison, Walter F.
Lafdjian, Jacob P. MA
Ostrander, Max H. AeE
Porzky, Victor D.
Yoler, Yusuf A. MS

1952

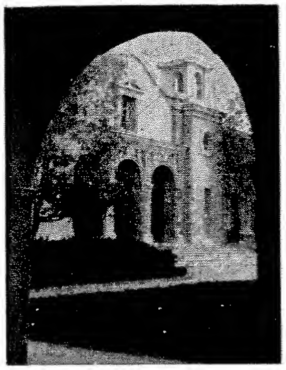
Abbott, John R. MS
Arcoulis, Elias G. MS
Dove, Joseph A. MS
Long, Ralph F. MS
Lunday, Adrian C. MS
Price, Edgar P. MS
Pruett, Jeter A. MS
Schaufele, Roger D. MS
Sutton, Don E.
Wiberg, Edgar MS

1953

Rankin, Fred W. Jr. MS
Strassenburg, Arnold MS
Vidal, Jean L.
Watson, Ronald MS

1954

Patraw, George W.
Pechacek, Robert E.



CALTECH CALENDAR

December, 1955

ALUMNI CALENDAR

January 12 — Winter Dinner Meeting, Rodger Young Auditorium

February 4 — Dinner Dance, Oakmont Country Club

April 7 — Annual Alumni Seminar Day

June 6 — Annual Meeting

June 23 — Annual Picnic

CALTECH ATHLETIC SCHEDULE

VARSITY BASKETBALL

January 7—
Cal Poly at Caltech

January 10—
Chapman at Caltech

January 13—
Occidental at Caltech

January 14—
Westmont at Caltech

January 17—
Caltech at Pomona

January 20—
Caltech at Nazarenes

January 21—
Caltech at Chapman

FRIDAY EVENING DEMONSTRATION LECTURES

December 16—
Floods—Dr. Norman Brooks

December 23, 30—
Christmas recess

January 6—
Origins of Southern California Landscape
—Dr. Richard Johns

January 13—
Air Pollution and Smog; A World-Wide Problem
—Dr. Frits Went

Glass turns salesman

—as photography speeds bottle design

Owens-Illinois Glass Company creates more than 3000 new bottle designs a year—uses photography to save time and costs in engineering them

Behind the sales-making lines of a handsome bottle lies a wealth of engineering. Much of this engineering is basic to whole groups of bottles. And this is where Owens-Illinois puts photography to work handling time-consuming chores in the drafting rooms.

Instead of redrafting recurring essentials, these elements are reproduced photographically from Kodalith Film prints kept on file. Then the new details are added and the finished working drawing produced. This saves hours of drafting time.

Reproducing engineering drawings is just one contribution photography makes to business efficiency. It microfilms valuable plans and specifications for safe storage. It examines new products with high-speed movies or x-ray photographs. It works for large businesses and small, speeding production, controlling quality, saving time and money.

Graduates in the physical sciences and in engineering find photography an increasingly valuable tool in their new occupations. Its expanding use has also created many challenging opportunities at Kodak, especially in the development of large-scale chemical processes and the design of complex precision mechanical-electronic equipment. Whether you are a recent graduate or a qualified returning serviceman, if you are interested in these opportunities, write to Business & Technical Personnel Dept., Eastman Kodak Company, Rochester 4, N. Y.

Eastman Kodak Company
Rochester 4, N. Y.

Put science-engineering backgrounds to work in new General Electric research facilities

Up-to-the-future facilities such as G.E.'s $5 million Metals and Ceramics Laboratory recently dedicated at Schenectady, N. Y., offer unlimited opportunity for qualified applicants with backgrounds of science or engineering.

Historically one of America's research leaders, G.E. continues to expand facilities across the nation for exploring new developments for the home, industry and defense. Research conducted in this Metals and Ceramics Lab, for example, is destined to provide new materials for applications ranging from rockets and atomic power plants to labor-saving appliances. Here, inspecting the surface of a casting, are George Colligan, RPI, and Allan Kiesler, Missouri School of Mines (white shirts).

For careers offering professional growth, investigate G.E.'s Engineering and Science Program. You will be trained in the field of science or engineering most suited to your interests and aptitudes—building on technical backgrounds in physics, chemistry, math or these engineering fields: mechanical, electrical, electronic, metallurgical, nuclear, chemical, aeronautical. 956-3

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Mr. W. S. Hill
Engineering Personnel
General Electric Company
Schenectady 5, N. Y.

Please send me your descriptive bulletin, ENS-P-5, on the G-E Engineering and Science Program.

Name ....

College .... Degree & Year ....

Address ....

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